

**Analysis of Alternatives
Blair Backup Property
Port of Tacoma
Tacoma, Washington**

Volume I

Prepared for



November 19, 1992

J-2350-20



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DATA QUALITY REVIEW AND
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EXECUTIVE SUMMARY

This Analysis of Alternatives Report is prepared for the Port of Tacoma in order to identify suitable alternatives for areas at the Blair Backup property requiring cleanup and to select a preferred alternative consistent with CERCLA and the Puyallup Settlement Agreement. This Analysis of Alternatives Report completes the analysis and reporting requirement of the Memorandum of Agreement (MOA) Section IIIB (1). This same effort is also being completed for the Blair Waterway property which is also to be transferred to the Puyallup Tribe under the Puyallup Settlement Agreement. These two documents should be reviewed together because the preferred cleanup action is combined for these two properties.

PROBLEMS IDENTIFIED FOR CLEANUP ASSESSMENT

The Final Investigation Reports for the Blair Backup property identified those specific problem areas requiring cleanup and further consideration. In summary, individual problem areas requiring cleanup and the associated cleanup objectives on the Blair Backup property include:

- ▶ **Slag-Contaminated Soils Containing Chromium and Arsenic**

Slag-contaminated soil impacts about 14 acres at the location of the former Ohio Ferro-Alloys (OFA) facility; about 80,000 cy of soil are involved ranging in depth from 1 to 6 feet. The source is predominantly OFA slag (about 30 percent) and to a lesser extent Asarco slag, estimated to be about 1 percent of the slag/soil material.

The cleanup objective for slag-contaminated soils is to prevent direct contact with arsenic and to prevent inhalation of chromium-containing dust.

- ▶ **Metals in OFA Ditch Surface Water**

The concern with metals is slag particulates found in ditch surface water at concentrations that slightly exceed freshwater copper, lead, and arsenic aquatic life standards. The source of the metals is Asarco slag which lines the ditch in local areas.

The cleanup objective for the OFA Ditch is to reduce the amount of slag particulates migrating to the ditch and from the site.

► **Charcoal- and PAH-Contaminated Soil**

Charcoal- and other carcinogenic PAH-contaminated soil impacts about 2 acres in the vicinity of the former OFA facility. There is approximately 4,100 cy of charcoal and 8,900 cy of soil occurring to depths of 6 feet. The source is related to former OFA operations.

The cleanup objective is to prevent direct contact with carcinogenic PAH materials.

► **Arsenic-Contaminated Sandblast Grit**

About 1,200 cy of illegally dumped sandblast grit mixed with soil were excavated from various property locations. Arsenic detected in the grit may be from Asarco slag which is known to leach metals. Initially the sandblast grit was excavated as a voluntary removal action; however, large volumes and the high cost of recycling or disposal warranted consideration with on-site alternatives.

The cleanup objective is to prevent direct contact with sandblast grit/soil containing arsenic and to protect against degradation of groundwater.

EVALUATION OF CLEANUP ALTERNATIVES

Our evaluation of cleanup alternatives for the Blair Backup property included refinement of cleanup objectives, then screening of a range of cleanup technologies for each of the problem areas in accordance with CERCLA. Viable alternatives were developed and a detailed evaluation of each alternative was completed as to the protectiveness, compliance with ARARs, long-term effectiveness, implementability, and cost. Criteria associated with future property use and the Puyallup Settlement Agreement documents were also considered. Cleanup options that would address the individual problem area concerns were subsequently identified, and a preferred alternative recommended.

Preferred Alternatives for Blair Backup Property Problem Areas

In the process of completing the Alternative Analysis, we concluded that problem areas could be more effectively addressed and managed over the long-term by consolidating and capping contaminated material in the OFA/Pennwalt Area of the Blair Backup property. Reasons for this conclusion are several. First, the relatively large acreage and volume of material impacted by OFA and Asarco slag and the minor hazard posed by these materials dictates an *in situ* remedy. Second, three of

the major site problems (the OFA slag, the Asarco slag in surface water discharges, and the PAHs in soil) are located in the same area. Third, screening of cleanup technologies shows the most feasible alternatives for each problem are compatible and the contaminants of concern can be addressed by the same technologies. Our conclusion was that cleanup objectives for all problem areas can be met by a combination of covering with clean sand and gravel and limited low permeability capping by paving. The specific preferred alternatives included:

► **Cover the Slag-Contaminated Soil and OFA Ditch Sediments with Clean Sand and Gravel Fill**

A 2-foot sand and gravel cover will prevent human contact with the arsenic, prevent inhalation of chromium dust, and eliminate slag particulates in the surface water runoff. This alternative is protective of human health and the environment and more cost-effective than other alternatives which meet the cleanup objectives.

► **Cover the PAH-Contaminated Soil with Sand and Gravel and Excavate and Dispose of Charcoal Briquettes Off Site**

The preferred alternative for the charcoal and PAH-contaminated soil is to remove and burn the charcoal in a permitted facility or dispose of the material in a solid waste landfill. If the charcoal/soil mixture qualifies as fuel and a cost-effective means of burning the material can be identified, the material will be burned. Alternatively, the Port of Tacoma proposes to dispose of the material in a solid waste landfill. The Roosevelt Regional Landfill (operated by Rabanco) and the Columbia Ridge Landfill (operated by Oregon Waste Systems) have, to date, been identified as potential disposal sites. Disposal of the charcoal/soil mixture in a solid waste landfill will be dependent upon Department of Ecology approval of the Port of Tacoma's "Petition for Exemption of Charcoal Briquettes and Associated Charcoal Contaminated Soils from Washington State Dangerous Waste Regulations, Chapter 173-303 WAC," dated November 9, 1992.

► **Include Sandblast Grit in OFA/Pennwalt Area beneath Sand and Gravel Cover and Low Permeability Asphalt Cap**

Because of the unexpected high volume and high disposal costs of the sandblast grit (in a landfill as a Washington State Dangerous Waste or recycled at a permitted recycling facility), we recommend placing the grit within the cover area of the OFA/Pennwalt Area. This alternative includes consolidating the grit within a small area above the water table and isolated from wood debris. The grit would be placed on sand and gravel fill and paved with a low permeability asphalt cap to prevent leaching of metals into the groundwater.

Combined Blair Properties Cleanup Alternative

For reasons similar to those described above, we further considered the option of removing and consolidating material from the Blair Waterway property within the same OFA/Pennwalt Area of the Blair Backup property proposed for sand and gravel cover and low permeability asphalt cap.

The Blair Waterway Property Final Investigation Report identified three problem areas associated with Asarco slag and arsenic in soil and sediments. The problem areas include Asarco slag and soil in the graving dock and upland areas surrounding the graving dock (18,000 to 20,000 cy), and slightly elevated concentrations of arsenic in the Weyerhaeuser Ditch sediments (80 cy). The cleanup objectives for the Blair Waterway property soils and sediments are to prevent direct contact and to protect groundwater. Refer to the Alternatives of Analysis for the Blair Waterway property for discussion and more detail on the Blair Waterway property issues (Landau, 1992).

The combined site alternative analysis considers excavation and removal of slag and Weyerhaeuser Ditch sediments from the Blair Waterway property and their placement and consolidation within the OFA portion of the Blair Backup property. Combining cleanup actions for the Blair Waterway and Blair Backup properties is desirable because it:

- ▶ Contains all contaminated soil in one area thus limiting long-term management requirements, including monitoring and institutional controls to one area;
- ▶ Poses less potential for environmental impact than the separate site cleanup this is because it is further removed from the Blair Waterway, there are limited pathways for contaminant transport to surface water bodies internal to the Blair Backup property, and long-term monitoring can be more effectively implemented to evaluate and address potential releases.
- ▶ It eliminate or reduces development controls for the majority of the Blair properties.

In Section 8 of this report we present a combined property cleanup action and our evaluation of this alternative.

PREFERRED ALTERNATIVE IS COMBINED CLEANUP

The overall preferred alternative for the properties is the combined property cleanup. The preferred alternative includes consolidating Asarco slag and the Weyerhaeuser Ditch sediments from the Blair Waterway property under a low permeability asphalt cap isolated from groundwater and wood debris, and placed on sand and gravel fill. These Blair Waterway property materials will be consolidated into an approximately 7-acre area on the Blair Backup property. In addition, about a 10-acre area containing primarily OFA slag would be covered by a two foot cover of compacted sand and gravel. PAH-contaminated soils would be covered with sand and gravel. Charcoal with carcinogenic PAHs would be removed and landfilled pending approval of the Port's Petition for Exemption.

ANALYSIS.ES

**ANALYSIS OF REMEDIAL ALTERNATIVES
BLAIR BACKUP PROPERTY
PORT OF TACOMA
TACOMA, WASHINGTON**

1.0 INTRODUCTION

The Blair Backup property is one of the six properties being transferred to the Puyallup Tribe pursuant to the Puyallup Tribe of Indians Settlement Act of 1989. This property is 85 acres in area and is located between Alexander Avenue and Taylor Way in the Commencement Bay tideflat area as shown on Figure 1-1. The Settlement Agreement requires that the transferred properties comply with appropriate federal or state contamination laws, can be used for commercial and industrial purposes, and that any cleanup undertaken is cost-effective. A Memorandum of Agreement (MOA) developed between the Port of Tacoma, the Puyallup Indian Tribe, the Washington State Department of Ecology, and the U.S. EPA facilitates implementation of the Settlement Agreement.

This report follows the "Final Investigation Report, Blair Backup Property", dated January 29, 1992, prepared for the Port of Tacoma and the Puyallup Tribe by Hart Crowser (1992a). The Final Investigation Report presents the conclusions of a 2-year site characterization effort which identified environmental quality issues associated with transfer of the property and any necessary cleanup.

The purpose of this report is to present the cleanup needs identified based on findings from the Final Investigation Report, and to describe the cleanup alternatives evaluation. First, this report summarizes the soil, groundwater, and surface water quality concerns; then presents cleanup objectives, and describes potential cleanup alternatives. Finally, we present the preferred alternatives given various site cleanup options. The goal of this work was to select a preferred cleanup alternative that will remedy the environmental quality issues identified, meet future site uses, and be practical in terms of cost.

1.1 Alternative Analyses Process and Organization of Report

The process followed in the analysis of cleanup alternatives is consistent with the requirements of the MOA and the substantive provisions of the CERCLA feasibility study process (EPA, 1988). The analysis of alternatives included:

- ▶ Identification of cleanup objectives and development of cleanup levels for all chemicals identified to pose potential human health or environmental risk using

chemical-specific applicable and relevant or appropriate requirements (ARARs);

- ▶ Development and screening of potential cleanup technologies;
- ▶ Formulation of viable alternatives and a detailed analysis of those alternatives as to protectiveness of human health and the environment, compliance with state and federal standards, short- and long-term effectiveness, implementability, reduction of toxicity, mobility, or volume, cost-effectiveness, and compatibility with future site development; and
- ▶ Selection of a preferred alternative.

The organization of this report generally follows the alternative analysis process. In the first few sections, we summarize the major findings from the Final Investigation Report including the site history, site hydrogeology, the areas identified for cleanup assessment based on potential for human health and environmental risk, and the cleanup goals and numeric cleanup levels developed based on chemical-specific ARARs.

The last four sections of the report present our evaluation of the cleanup alternatives. Our cleanup alternative evaluation includes separate assessment of slag-contaminated soil alternatives, PAH-contaminated soil alternatives, and the combined Blair Backup property and Blair Waterway property alternative. The Alternatives Evaluation is organized as follows:

- ▶ **Section 4—Evaluation of Alternatives for OFA Area Slag-Contaminated Soils**
We identify remedial alternatives and screen them relative to applicability to specific contaminants and cleanup objectives, cost, and implementability.
- ▶ **Section 5—Evaluation of Alternatives for PAH-Contaminated Soils**
We identify remedial alternatives and screen them relative to applicability to specific contaminants and cleanup objectives, cost, and implementability.
- ▶ **Section 6—Evaluation of Alternatives for Sandblast Grit-Contaminated Soil**
We evaluate alternatives for disposal of sandblast grit and associated soil removed as part of a voluntary action.
- ▶ **Section 7—Summary of Preferred Alternatives for Blair Backup property only**
We combine the recommended alternative for remediation of contamination due to slag and the recommended alternative for remediation of contamination

due to the OFA and Asarco slag on the Blair Backup property, and cPAHs, concerns into the Preferred Alternative for remediation.

► **Section 8—Combined Blair Properties Cleanup Alternative**

We offer the alternative of placing Asarco slag-contaminated soils from the Blair Waterway property onto the OFA area of the Blair Backup property.

Tables and figures pertaining to discussions in the text are presented at the end of their respective sections. Supplemental documentation are presented in appendices after the main text in this volume. A compilation of supporting laboratory data for specific appendices is presented in a separate volume. The appendices include the following:

Appendix A - Vinyl Chloride in North Site Area Groundwater

Appendix B - Surface Water and Sediment Quality in the Reichhold S Ditch

Appendix C - Surface Water Quality in the OFA Ditch

Appendix D - *In Situ* Characteristics of the Soil/Slag Material in the OFA/Pennwalt Area - Supplemental Site Assessment

Appendix E - PAH-Contaminated Material

Appendix F - Potential ARARs Considered for Development of Cleanup Objectives and Evaluation of Remedial Alternatives

Appendix G - Cost Estimates for Alternatives

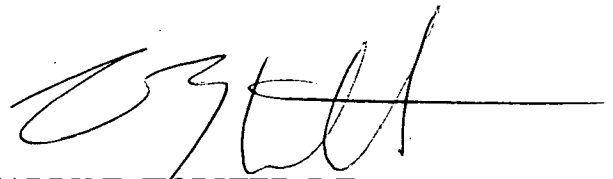
Appendix H - Excavation, Stockpiling, and Characterization of Sandblast Grit

1.2 Signatures of Preparers

The undersigned individuals have been responsible for the preparation of this document. Questions or comments about this document or the described work should be addressed to any of them.



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Scale in Feet



HARTCROWSER
J-2350-20 8/92
Figure 1-1

2.0 BACKGROUND INFORMATION

2.1 *Site Description*

The Blair Backup property is an x-shaped parcel about 85 acres in area as shown on Figure 2-1. To the north, it is bordered by Taylor Way and Atochem, to the west by Reichhold Chemicals Inc., to the south by Alexander Avenue, and to the east by Kaiser Aluminum and Chemical. The property lies in the central area of the peninsula between the Blair and Hylebos waterways. The property is relatively flat and was created by filling of tideflat with sediments dredged from the initial construction of the Blair and Hylebos waterways.

The site is located in a highly developed, industrial area and is zoned M-3 Heavy Industrial by the City of Tacoma. The surrounding industrial facilities—Atochem, Reichhold Chemicals Inc., and Kaiser Aluminum and Chemical Inc.—have had documented chemical releases onto the Blair Backup property. Primary contaminant sources at these adjacent properties are being addressed or have been removed. Residual cleanup either has been completed or is in the process of being completed on the Blair Backup property.

For the purposes of discussing environmental issues, the property was divided into four areas during the site characterization effort. These areas as shown on Figure 2-1 are based largely on past land uses, hydrology, and differences in environmental quality issues. The areas include:

- ▶ **The Ohio Ferro-Alloy (OFA)/Pennwalt Area** which occupies the 21-acre eastern leg of the property, is the site of the former Ohio-Ferro alloy smelter, and bounds on a portion of the Atochem facility;
- ▶ **The North Site Area** which occupies roughly 11 acres in the northwestern portion of the property;
- ▶ **The General/Fill Area** which is the largest portion occupying about 46 acres in the central and southern portion of the property; and
- ▶ **The Alexander Avenue Strip Area** which occupies a 7-acre rectangular piece of land between Alexander Avenue and the Reichhold Chemical facility.

2.2 Summary of Final Investigation Report

2.2.1 Site History

The site has experienced limited use relative to its size and location. Most of the site is undeveloped; however, there were several historical uses in local areas of the property that were identified and investigated. These uses included:

- ▶ A ferrosilicate and ferrochromium manufacturing plant referred to as Ohio Ferro-Alloy (OFA). The Ohio Ferro-Alloy Corporation operated their smelter in the southeastern 20 acres of the property (OFA/Pennwalt Area) between 1941 and 1974 as shown on Figure 2-2. The plant was demolished in 1975 prior to acquisition of this portion of the property by the Port of Tacoma. Residual slag, charcoal, and demolition debris which includes burned wood are the principal remaining issues related to the OFA operations.
- ▶ Between 1975 and 1989 the easternmost area of the property was leased to various timber companies (Murray Pacific, Cascade Timber, and Plum Creek Timber Co.) for the purpose of log sorting and storage. It is likely that Asarco slag found on the property are related to these activities.
- ▶ Two small commercial facilities operated in the northeastern corner of the property (OFA/Pennwalt Area) from about 1975 until 1990. These included a truck washing facility and a small truck repair facility as shown on Figure 2-2. The buildings for these past services remain. An underground storage tank and minor contaminated soil associated with the tank were removed in 1990 in the area of these facilities.
- ▶ The illegal dumping of sandblast waste was identified in several locations on the property as shown on Figure 2-2. The largest waste area was in the northcentral North Site Area. Several smaller areas were identified in the General/Fill Area and the Alexander Avenue Strip Area. The sandblast grit and intermingled soil has been excavated and stockpiled in the North Site Area as a voluntary removal action.

In addition to these site uses, the historical practices on adjacent properties which have contributed to environmental quality concerns on the property include:

- ▶ A former Kaiser Aluminum and Chemical Corporation sludge pond in the east side of the General/Fill Area which contained PAH-contaminated soil. Soil

removal was completed under an Ecology MTCA Consent Decree in December 1990.

- ▶ Contaminated soil in Reichhold's Solid Waste Management Unit 49 on the eastern side of the Alexander Avenue Strip Area which was also removed in 1990 under RCRA Correction Action program.
- ▶ Marginally contaminated groundwater in the Intermediate Aquifer in wells in southwestern corner of the General/Fill Area. Reichhold's groundwater remediation system which will capture this groundwater is in the design and performance phases of implementation.
- ▶ Leakage from above-ground storage tanks on the Atochem parcel which abuts the OFA/Pennwalt Area (Ag-Chem or Wypenn Area) which appears to have contributed to high pH groundwater conditions along the boundary between the Blair Backup property and the Ag-Chem property. These tanks are empty and planned for disposition.

2.2.2 Hydrogeologic Setting

The property lies within the central area of the peninsula between the Blair and Hylebos waterways. The soil stratigraphy includes silty sand dredge material and other fills overlying native tideflat silts and deeper marine and alluvial sequences. The silty sand fill comprises the Shallow Aquifer. The Shallow Aquifer is underlain by native tideflat silts which comprise the Upper Aquitard at the site. The Intermediate Aquifer is confined beneath the Upper Aquitard. The soil and water quality concerns identified on the property were found in the fill and the Shallow Aquifer.

On-site surface water either drains internally or discharges through man-made ditches to off-site ditches which eventually discharge to either the Blair or Hylebos waterways. There are two major ditches which drain the site; the OFA Ditch in the eastern OFA/Pennwalt Area and the Reichhold S Ditch which parallels the Reichhold facility boundary along the northern side of the Alexander Avenue Strip Area as shown on Figure 2-3. The OFA Ditch flows intermittently, is commonly blocked with wood debris at the outfall, and has been reconstructed at slightly different locations several times over the past few years. The Reichhold S Ditch is a deep (over 8 feet), well-defined channel that is tidally influenced.

Groundwater in the silty sand fill flows at low rates, generally toward the Reichhold S Ditch or toward Taylor Way. In the OFA/Pennwalt Area, most of the

groundwater flows toward Taylor Way. In the North Site Area, the groundwater flows both toward Taylor Way in the north and toward the Reichhold S Ditch in the south. Groundwater in the General/Fill Area flows to the north toward the Reichhold S Ditch. Figure 2-3 shows generalized groundwater flow directions. The groundwater flow rates are very low and variations in these flow directions occur locally and with seasonal changes.

Before reaching the Hylebos Waterway, groundwater flowing toward Taylor Way travels beneath the Atochem facility or is intercepted by the backfill material which surrounds the sewer lines beneath Taylor Way. Groundwater which discharges to the Reichhold S Ditch, continues onto the tidally influenced Lincoln Avenue Ditch and eventually to the Blair Waterway.

2.2.3 Areas Identified for Further Evaluation

Former site uses, activities related to adjacent facility operations, illegal dumping, and filling activities on the property have resulted in an impact to the environmental quality of some of the soils, groundwaters, and surface waters at the property. A human health and environmental risk assessment was conducted in conjunction with evaluation of the physical and chemical site conditions to determine potential cleanup needs. Based on these analyses, there were four potential contamination issues identified for further evaluation in the Final Investigation Report (Hart Crowser, 1992a). These included:

- ▶ Charcoal and PAH-contamination in the OFA/Pennwalt Area soil;
- ▶ Slag-containing metals in the OFA/Pennwalt Area soil and sediment;
- ▶ Vinyl chloride in the North Site Area groundwater; and
- ▶ Elevated metal concentrations in the Reichhold S Ditch surface water and sediment.

Of the four issues identified, only the slag and the charcoal require cleanup evaluation based on potential human health and environmental concerns. Additional data collection and analyses of the North Site Area groundwater indicate the previous concern with vinyl chloride no longer exists. Data collection and analyses of the Reichhold S Ditch surface water and sediment indicate source control has improved sediment quality and the elevated metals in the surface water are a natural phenomenon. The concerns associated with each of these issues is summarized in the following subsections and in detail in Appendices A and B.

Most of the supporting data and analyses for these contamination issues are presented in the Final Investigation Report. Additional explorations and chemical

testing conducted during the current phase to confirm hypotheses or better understand the nature and extent of contamination, are presented in appendices to this report.

2.2.3.1 Charcoal and PAH-Contaminated Soil in OFA/Pennwalt Area Soil

Soils. Approximately 13,000 cubic yards (cy) of surface and near-surface soils contaminated with carcinogenic polycyclic aromatic hydrocarbons (cPAHS) were identified in the westcentral OFA/Pennwalt Area. The cPAHs are related to a pocket of charcoal briquettes and a nearby area where the OFA smelter demolition debris is mixed with the soils. The area of cPAH occurrence is about 2 acres in area. Highest total cPAH concentrations were detected in individual charcoal samples at concentrations ranging up to about 9,400 milligrams per kilogram (mg/kg). The cPAH concentrations in the soil and charcoal mixtures ranged from 5 to 8,900 mg/kg. Total cPAH concentrations in the surrounding area of debris mixed with the soil ranged from non-detectable to a maximum of 1,500 mg/kg in one location. An outline of the extent and distribution of soils containing cPAHs is presented on Figure 2-2. More detailed discussion is presented in Appendix E.

Groundwater. PAHs were detected in unfiltered groundwater samples collected within the vicinity of the soil, charcoal, and debris areas discussed above. PAH concentrations in the groundwater are at least partly attributable to particulate matter present in the water samples. PAHs are generally immobile in water and have not been detected in groundwater sampled from wells located hydraulically downgradient of the soil contamination area.

Potential Human Health and Environmental Risk. The cPAHs present a potential human health risk associated with future direct contact exposures to industrial site workers (Hart Crowser, 1992a). A potential excess lifetime cancer risk of 6×10^{-4} was estimated for the reasonable maximum exposure (RME) condition. The cPAHs are not transported off site via groundwater or surface water pathways because of their low mobility, so pose no risk to aquatic life.

2.2.3.2 OFA and Asarco Slag in OFA/Pennwalt Area Soil, Sediment, and Surface Water

Soil. The upper 1 to 6 feet of soil in the OFA/Pennwalt Area contains a mixture of wood chips, rock, wood and concrete debris, and slag. The soil/slag material includes about 80,000 cy distributed over 17 acres. Most of the slag is from the former OFA smelter operation. A much smaller percentage of the slag appears to be Asarco slag, presumably brought onto the property incidentally during former log

yard operations. Locally, the slag contains elevated concentrations of metals. Chromium (OFA slag) and arsenic (Asarco slag) were the principal constituents of concern detected in these materials. Only chromium and arsenic present potential human health risks under the future RME scenario.

Figure 2-2 presents the approximate extent of soil/slag material in the OFA/Pennwalt Area. Figure 4-1 presents the exploration locations and detailed delineation of the boundary of the soil/slag material. The soil/slag material includes approximately 30 to 35 percent slag; the slag is predominantly of OFA origin with about 1 percent comprising Asarco slag. See Appendix D for additional information on the soil/slag characterization.

Groundwater. The metals in the slag/soil material do not appear to be leaching into the groundwater system in any substantial amount. In the thickest and most central areas of slag occurrence in the soil fill as shown on Figure D-4 in Appendix D, groundwater from wells HC-11S, HC-12S, HC-15S, HC-16S exhibited low or undetectable (U) concentrations of chromium and arsenic, the metals of concern within OFA slag and Asarco slag, respectively. Arsenic concentrations in milligrams per liter (mg/L) were 0.027 and 0.013 in HC-11S, 0.005 in HC-12S, 0.005U and 0.005U in HC-15S, and 0.010U and 0.010U in HC-16S. Chromium concentrations in mg/L were 0.039 and 0.016 in HC-11S, 0.010U in HC-12S, 0.010U and 0.002 in HC-15S, and 0.010U and 0.005 in HC-16S.

The Toxicity Characteristic Leaching Procedure (TCLP) and Extraction Procedure Toxicity (EP Tox) testing of soil/slag samples also indicate that the OFA slag is not leachable. Out of five slag-containing fill samples analyzed using the TCLP test and eight samples analyzed using the EP Tox test, no chromium was detectable. Out of the same thirteen samples (5 TCLP and 8 EP Tox), only one sample leached arsenic above detection levels at a low concentration of 0.42 mg/L (as compared to the hazardous waste level of 5.0 mg/L).

Elevated concentrations of several metals including arsenic and chromium were identified surrounding Atochem's Ag-Chem (or Wypenn) property boundary. Releases of arsenic and alkaline salts (high pH) attributable to the adjacent property use is the likely source. For example, the highest arsenic concentrations (range 0.190 to 0.640 mg/L) were detected in shallow groundwater monitoring wells HC-4S, HC-5S, and HC-6S installed immediately adjacent to the Atochem facility and outside of the area of slag occurrence. Similarly, the most alkaline conditions (pH 11) detected at the Blair Backup property were observed in the shallow groundwater wells (HC-4S had a pH of 11.1) installed immediately adjacent to the Pennwalt

Ag-Chem (Atochem) facility. The high pH condition of these groundwaters results in the mobilization of arsenic and other naturally occurring metals.

Surface Water. Elevated arsenic, copper, and lead concentrations have been found in surface water from the OFA/Pennwalt Area. The total arsenic concentrations measured in the OFA Ditch surface water ranged from 0.024 to 0.160 mg/L and dissolved arsenic ranged from 0.033 to 0.180 mg/L. Total and dissolved copper concentrations ranged between 0.020 and 0.240 mg/L and 0.001 to 0.042 mg/L, respectively. Total lead concentrations ranged from 0.007 to 0.010 ug/L, and dissolved lead concentrations ranged from non-detect to 0.005 ug/L. The source of metals to the OFA Ditch surface water appears to be erosion and dissolution of Asarco slag which is scattered in the area around the ditch. (See Appendix C for a summary of the surface water data collected in the OFA Ditch including additional sampling and analysis conducted since the Final Investigation Report.)

Impacts to the environment from metals in surface water discharges are not expected, because the metals levels in the ditch (which is freshwater) meet freshwater aquatic life criteria. In addition, the surface water is mixed and diluted by at least 20 times and up to 100 times in the Kaiser Ditch prior to reaching the Hylebos Waterway eliminating any potential to impact the marine environment. Neither arsenic, copper, nor lead were found above detection levels in surface water samples collected from the Kaiser Ditch (Atochem, 1990).

The total (or unfiltered) copper concentrations exceed the freshwater aquatic life criteria. Total lead concentrations also slightly exceed or just meet the freshwater criteria. Because concentrations of both dissolved copper and lead meet the cleanup criteria it appears that control of slag particulate discharges to the ditch will control the surface water metal concentrations in site discharges.

OFA Ditch Sediment. Sediments within the OFA Ditch contained elevated concentrations of arsenic and copper. An excess RME lifetime cancer risk of 2×10^{-5} is associated with potential direct contact with the sediment containing arsenic in the OFA Ditch. The sediment quality concerns will be addressed concurrently with the soil/slag concern identified in the OFA/Pennwalt Area.

Potential Human Health and Environmental Risk. The only potential risks identified with the slag in the OFA/Pennwalt Area is from the inhalation of chromium dust and direct contact with soil and sediment containing arsenic. Minimizing long-term dust emissions, direct contact, and soil ingestion of the fill-containing slag will reduce these potential risks.

No human health risks or environmental risks were identified associated with the OFA Ditch surface water discharges. Further, the risk assessment conducted as part of the Commencement Bay Nearshore Tidelat RI/FS (Tetra Tech, 1989) concluded that the arsenic exposure through fish consumption in Commencement Bay does not pose a human health risk, based on the level of arsenic observed in fish tissues.

2.2.3.3 Vinyl Chloride in North Site Area Groundwater

Vinyl chloride was detected in shallow groundwater within the North Site Area at concentrations ranging from 0.005 to 0.086 mg/L during the site characterization work. No known sources of chlorinated solvents exist in the North Site Area; however, a former septic tank area located hydraulically upgradient on the adjacent Reichhold property was identified as a potential source.

The vinyl chloride was identified as a potential future human health concern in the Final Investigation Report, due to potential inhalation of vapor releases. However, more recent groundwater sampling has indicated a statistically significant ($P < 0.05$) decline in vinyl chloride concentrations in this area. Vinyl chloride concentrations measured in February 1992 were over an order of magnitude lower than previous concentrations. The decrease in vinyl chloride concentrations likely reflects previous source controls and the volatilization of residuals from groundwater to air.

Based on the current levels of vinyl chloride in North Site Area groundwater, no current or future human health or environmental risk exists (See Appendix A). Incorporation of the recent vinyl chloride data into the risk assessment indicates that current potential RME cancer risks are less than the 1×10^{-5} goal. Based on the observed degradation trend (See Figure A-2, Appendix A) future risks will be even lower. Since no other human health or ecological concerns were associated with vinyl chloride at the Blair Backup property, this contaminant was not considered further in the analysis of cleanup alternatives.

2.2.3.4 Nickel and Zinc in Reichhold S Ditch Surface Water

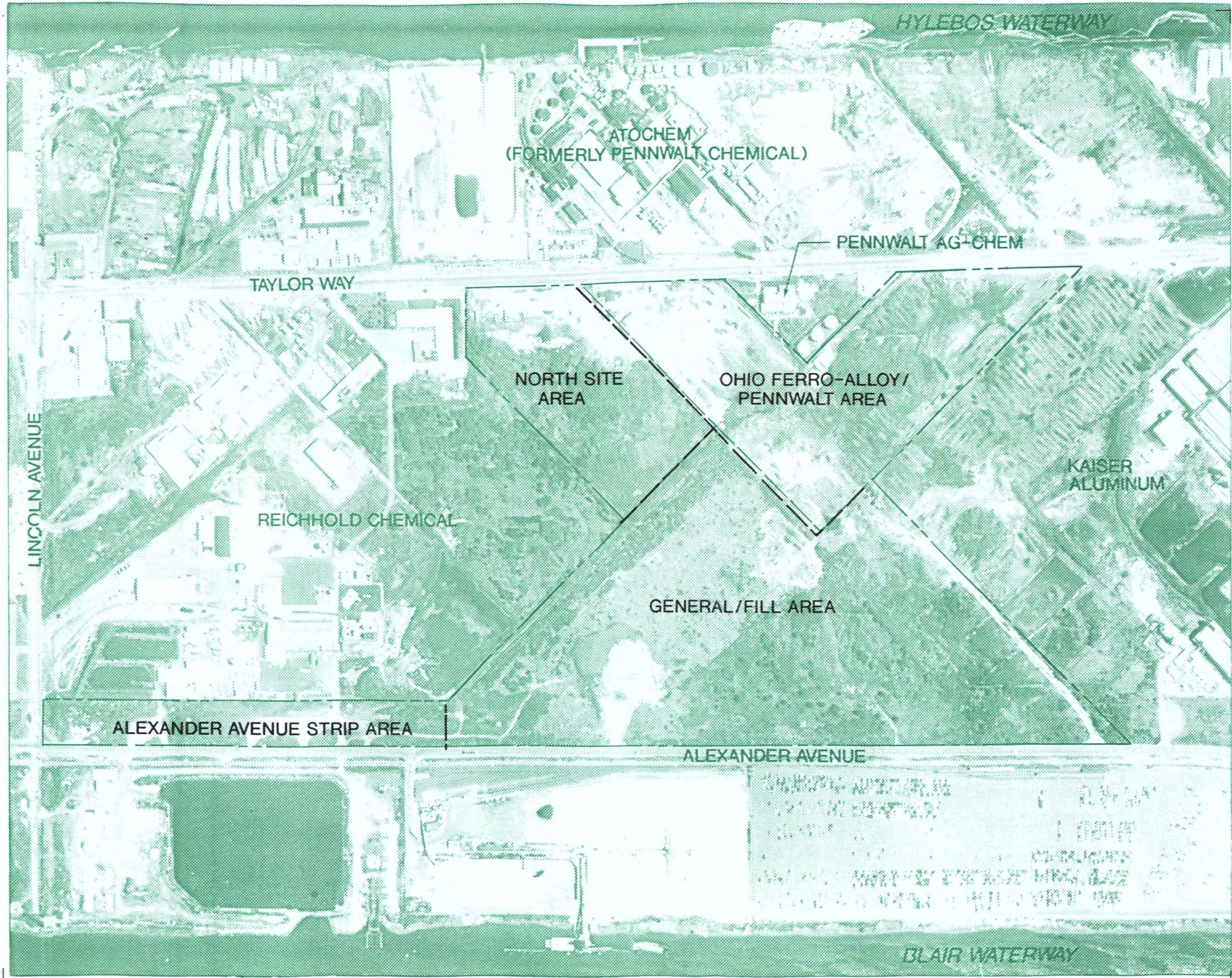
Nickel and zinc concentrations were detected in surface water samples collected from the Reichhold S Ditch at concentrations above those identified as protective of marine aquatic life. However, the source of these metals to the ditch water which is from groundwater within the General/Fill Area, appears to be a natural condition. Specifically, the natural acidity of General/Fill Area groundwater (to pH 4.6; typical of highly organic marsh soils) apparently mobilizes naturally occurring metals such as nickel and zinc into solution (See Technical Memorandum, Appendix B).

The Reichhold S Ditch is primarily a freshwater ditch although it is tidally influenced. The Reichhold S Ditch surface waters are in overall compliance with hardness-dependent freshwater aquatic life criteria. For these reasons, nickel and zinc concentrations in the Reichhold S Ditch were not considered in the cleanup alternatives analysis.

2.2.4 Sandblast Grit Excavated as Voluntary Action

Sandblast grit was excavated in several areas of the site as part of a voluntary cleanup action, as shown on Figure 2-2. Originally the sandblast material was believed to be on the surface and of minimal extent, but was found to be more extensive and intermingled with fill soils to the depth of the water table in two locations in the North Site Area. Currently there are approximately 1,000 cubic yards of material stockpiled on site. Waste characterization testing indicates the material may be considered a Washington State Dangerous Waste if removed from the site. See Appendix H for the chemical characteristics of the sandblast grit-contaminated soil. See Appendix F for discussion of potentially applicable requirements for the sandblast grit disposal. Because of the much larger than expected extent of contaminated material it was decided that it is appropriate to include cleanup of the sandblast grit-contaminated soil within the overall cleanup of the property.

Property Areas Map



Note: Base map prepared from aerial photograph of the Port of Tacoma dated June 1, 1989.

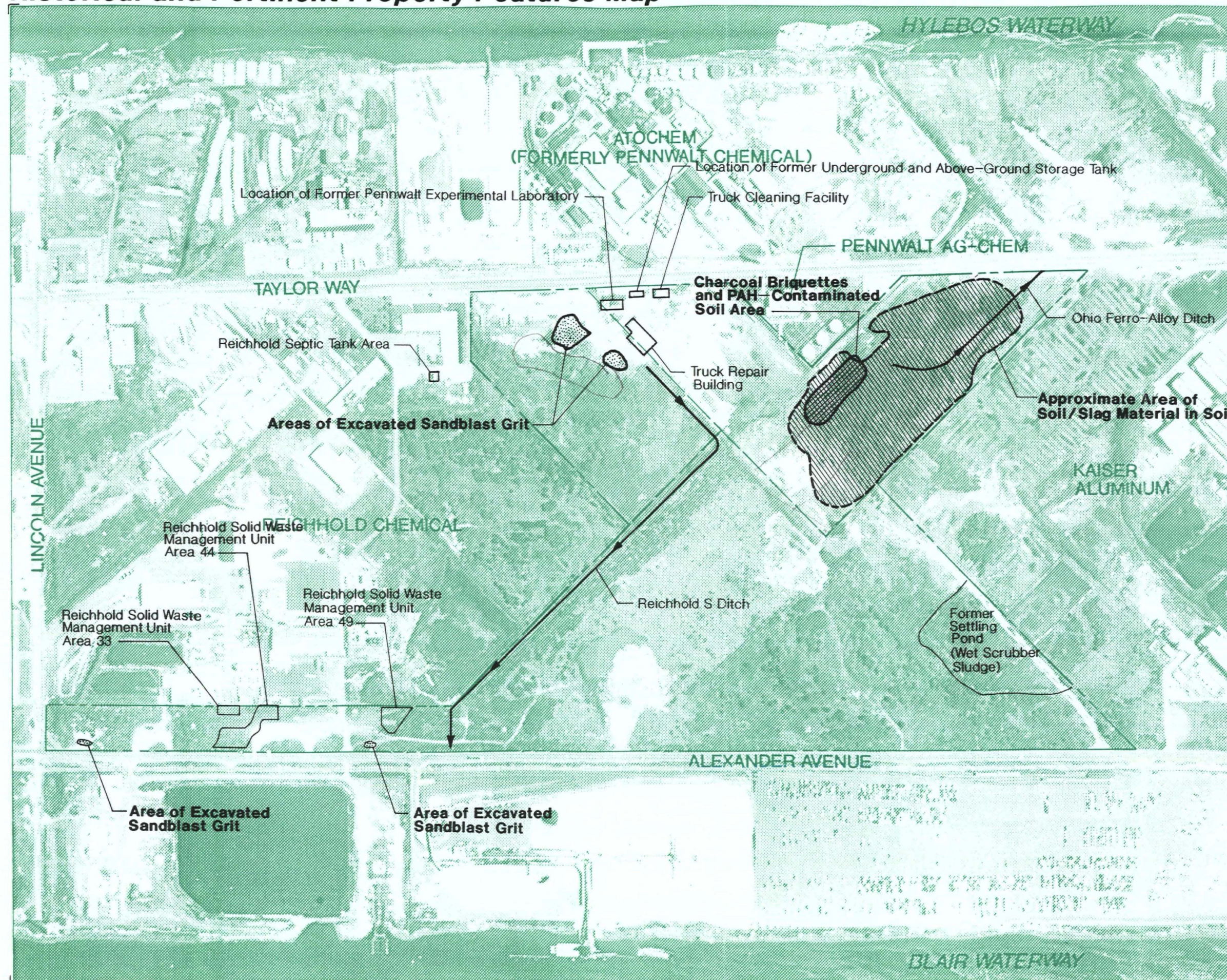


0 400 800
Approximate Scale in Feet



HARTCROWSER
J-2350-20 6/92
Figure 2-1

Historical and Pertinent Property Features Map

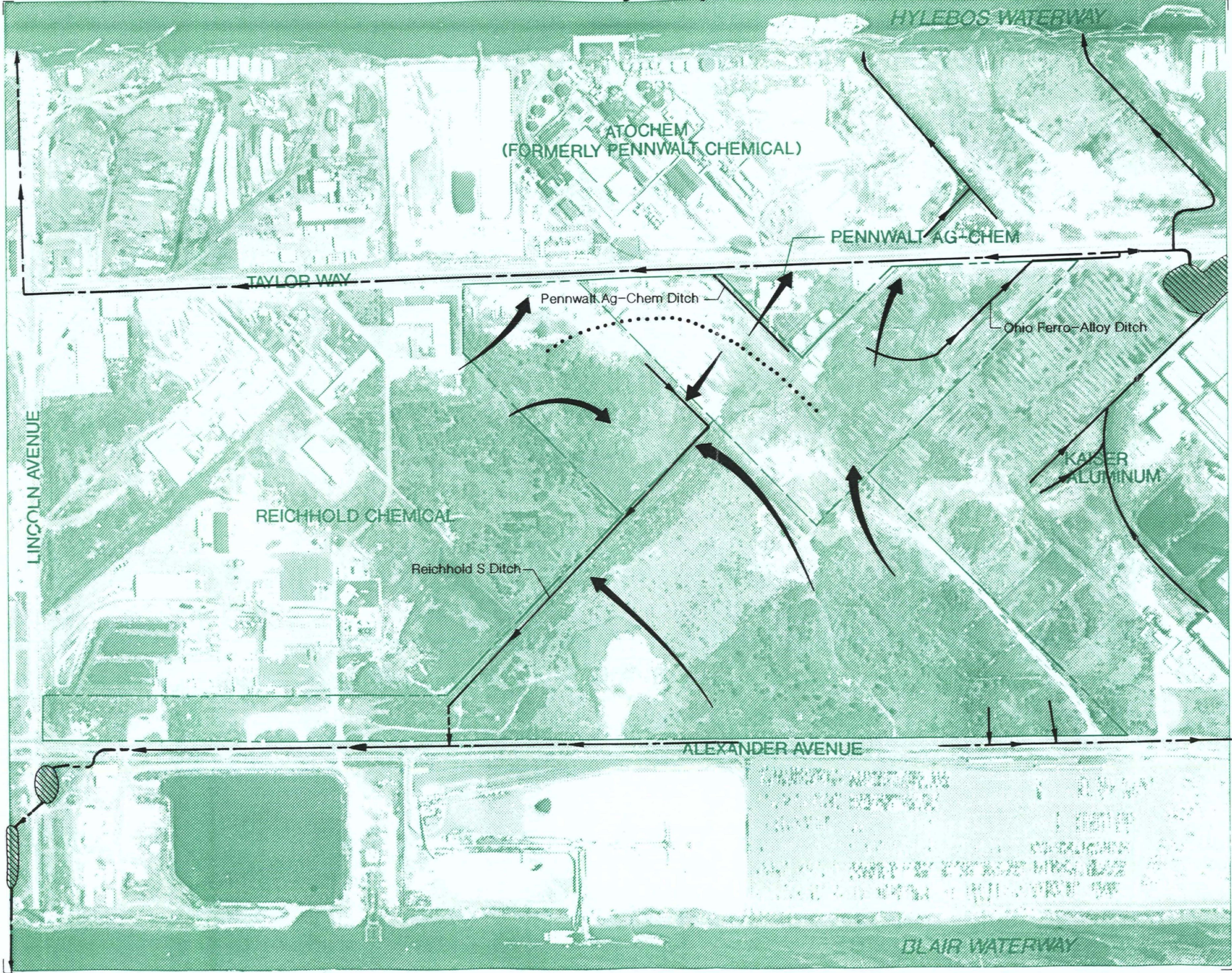


Note: Base map prepared from aerial photograph of the Port of Tacoma dated June 1, 1989.



0 400 800
Approximate Scale in Feet

Surface Water and Groundwater Flow Pathways Map



- Closed Surface Water Drainage
- Open Surface Water Drainage
- Generalized Groundwater Flow Direction
- Approximate Location of Groundwater Divide. Varies with the Season.

Notes: 1. Off-site drainage data obtained from the Commencement Bay-Nearshore/Tideflats Area Drainage Map (TPCHD, 1988) with modifications made based on January 1991 observations.

2. Base map prepared from aerial photograph of the Port of Tacoma dated June 1, 1989.



0 400 800
Scale in Feet

3.0 CLEANUP OBJECTIVES

The general objective of the cleanup actions being considered for the Blair Backup property is to provide a cost-effective remedial alternative that effectively mitigates and minimizes threats to human health and the environment. The cleanup objectives define an acceptable concentration or concentration range for each constituent of concern identified for each medium. The cleanup objectives are developed in accordance with the National Contingency Plan (NCP; 40 CFR Part 300), the Washington State Model Toxics Control Act Cleanup Regulation (MTCA; Chapter 173-340 WAC), and the interim final EPA Guidance Document entitled *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA, 1988b).

This section of the report first summarizes the chemicals and media identified for cleanup alternative evaluation. Next, we describe the criteria and considerations used to develop cleanup goals for each of the problem chemicals. Finally, we propose numeric cleanup levels for the site. The practicability of achieving these goals using alternative remediation technologies is assessed in subsequent sections of this report.

3.1 *Identification of Chemicals and Media of Concern*

The chemicals and media identified for cleanup alternative evaluation are based on the results of an extensive site characterization, risk assessment, and screening of the data with potentially applicable or appropriate and relevant requirements (ARARs). The results of these evaluations are presented in the Final Investigation Report prepared for the property and are summarized in the preceding section of this report. The identified concerns remaining at the site for which cleanup alternatives are developed include:

- ▶ **Chromium and Arsenic in Soil and Sediment in the OFA/Pennwalt Area.**
Both direct contact (arsenic) and fugitive dust inhalation (chromium) risks were identified (RME risk of 2×10^{-5}); the highest metal concentrations were associated with OFA slag (chromium) in the westcentral OFA/Pennwalt Area soils and Asarco slag (arsenic) in the eastern OFA/Pennwalt Area soil and OFA Ditch sediment.
- ▶ **Copper, Arsenic, and Lead in Surface Water in the OFA/Pennwalt Area.**
Particulate concentrations of copper in surface water may exceed levels protective of sensitive aquatic life. During various sampling events arsenic and lead have also been detected in surface waters in particulate form. Addressing

slag particulates in the surface water discharges will also control the potential for copper, arsenic, and lead to be transported in surface water.

- ▶ **Carcinogenic PAHs in the Central OFA/Pennwalt Area.** Direct contact risks were identified for cPAH-contaminated soil (RME risk of 6×10^{-4}); the cPAHs are associated with charcoal briquettes, soil mixed with charcoal, and a small amount of demolition debris of the former OFA smelter.

3.2 Development of Cleanup Levels

The cleanup levels were developed based on a review of ARARs promulgated under federal and state law and other "To Be Considered" (TBC) advisories and guidelines related to this particular site. These ARARs are presented in Appendix F. The chemical-specific ARARs most pertinent to the cleanup of this property include:

- ▶ Model Toxics Control Act (MTCA, Chapter 173-340 WAC);
- ▶ Water Quality Standards for Surface Waters (Chapter 173-201 WAC); and
- ▶ Clean Water Act (40 CFR 136),

The cleanup levels are derived using the Washington State MTCA Cleanup Regulation (Chapter 173-340 WAC) and the federal and state surface water quality standards. Use of MTCA essentially incorporates the other two ARARs. MTCA is similar in methodology to CERCLA, although the state methodology generally results in more stringent cleanup levels and a narrower range of cancer risk targets.

3.2.1 Use of MTCA

Method A was used to establish cleanup levels for the Blair Backup property soils since the cleanup involves a limited number of commonly encountered contaminants. Method A is appropriate for this site as the remedial actions being contemplated for the property are considered "routine" under the definitions provided in WAC 173-340-130 (i.e., the cleanup actions involve contaminated soils, and the cleanup alternatives under consideration are obvious and proven technologies capable of achieving the cleanup levels). In addition, Method A standards are available for all indicator chemicals and media of concern.

Method B freshwater criteria were used to establish cleanup levels for surface water in the OFA/Pennwalt Area. Method B is applicable to all sites and is a risk-based method for setting cleanup levels at sites with multiple contaminants. ARARs are also considered when establishing Method B cleanup levels. Method B freshwater

cleanup levels were applied to the OFA/Pennwalt Area surface water since the water is primarily fresh (total dissolved solid content is less than 1,000 mg/L) and has the potential to support freshwater organisms in the OFA Ditch. The Method B freshwater cleanup levels for the constituents of concern in OFA/Pennwalt Area surface water (arsenic, copper, and lead) were based on the Washington State Water Quality Standards for Surface Waters (Chapter 173-201 WAC) and the federal Clean Water Act (40 CFR 136) aquatic life chronic criteria.

Other criteria considered in our evaluation of MTCA cleanup levels are discussed below. These criteria include current and future industrial land use, the inadequacy of groundwater for drinking water supply, development of drainage ditch sediment criteria, and evaluation of multiple exposure pathways.

3.2.1.1 Industrial Site Use

For certain media such as soils, MTCA determines different cleanup levels depending upon reasonable maximum exposure (RME) given land use considerations (e.g., industrial versus residential use). We have applied MTCA industrial cleanup levels (WAC 173-340-745(1)) based on the following factors:

- ▶ The site is currently zoned for industrial purposes and is surrounded by properties being used for industrial activities; and
- ▶ The Blair Backup property has a history of industrial use and will remain industrial under the Puyallup Settlement Agreement and the Port/Tribe Implementing Agreement.

3.2.1.2 Groundwater Use

The potential for groundwater underlying the Blair Backup property to be used for water supply was discussed in detail in the Final Investigation Report (Hart Crowser, 1992a). Briefly, shallow groundwaters would support a very limited yield (less than 0.5 gallon per minute). Further, the groundwater in the deeper Intermediate Aquifer is highly saline. For these reasons, potential future water supply uses of the Shallow and Intermediate Aquifers is not considered in the development of groundwater cleanup levels under WAC 173-340-720. In addition, institutional controls prohibiting use of groundwater on the site are proposed as part of the property transfer conditions. Cleanup levels applicable to groundwater were based on marine surface water protection.

3.2.1.4 Drainage Ditch Sediment

There are currently no state or federal freshwater sediment criteria which could be used to establish cleanup levels for drainage ditch sediment. We applied MTCA industrial soil cleanup levels to evaluate the OFA Ditch sediment quality because the sediments are essentially the same material as the soil/slag mixture observed throughout the site. Additionally, the ditch is dry for long periods of time (estimated to be 50 percent of the time) when direct contact concerns would apply.

3.3 Blair Backup Property Cleanup Objectives

Cleanup objectives for OFA/Pennwalt Area soils and surface water are presented in Table 3-1. We discuss the rationale for each of the cleanup objectives in the following sections.

3.3.1 OFA/Pennwalt Area Soil

3.3.1.1 Arsenic Cleanup Level

The cleanup objective for arsenic in OFA/Pennwalt Area soil includes the prevention of direct contact or ingestion of soils containing concentrations exceeding 200 mg/kg. The 200 mg/kg criteria is based on the MTCA Method A industrial cleanup level. We believe that this cleanup level will also be protective of groundwater and surface water since:

- ▶ We currently do not exceed the MTCA freshwater surface water cleanup level of 0.19 mg/L despite having soils in these areas with concentrations exceeding 200 mg/kg of arsenic. In addition, the principal receptor, the Kaiser Ditch meets marine criteria for arsenic (Atochem, 1990).
- ▶ The only area exceeding the MTCA groundwater cleanup level for arsenic is adjacent to the former Pennwalt Ag-Chem (Atochem) facility. We believe that the presence of alkaline water in this area, which is probably derived from above-ground sodium hydroxide tanks located on the Atochem property, greatly enhances the mobility of arsenic. If the groundwater pH in this area is decreased to typical background conditions, arsenic concentrations in groundwater will likely be significantly reduced.

3.3.1.2 Chromium Cleanup Level

The cleanup objective for chromium in OFA/Pennwalt Area soils is based on preventing dust generation (and subsequent worker inhalation) from soils containing chromium concentrations exceeding 500 mg/kg. The 500 mg/kg cleanup level is based on MTCA Industrial Method A criteria.

This cleanup level should also be protective of groundwater and surface water because chromium meets all marine surface water quality criteria. In addition chromium was not detected in TCLP leachates of the OFA/Pennwalt Area soils, including samples of OFA slag.

3.3.1.3 cPAH Cleanup Level

The cleanup objective for cPAHs in OFA/Pennwalt Area soils includes preventing direct contact or ingestion of soils containing total cPAHs in excess of 20 mg/kg. The 20 mg/kg cleanup level is based on MTCA Industrial Method A criteria. This value should also be protective of groundwater since:

- ▶ cPAHs were not detected in the TCLP leachates of OFA/Pennwalt Area soils including samples containing over 8,000 mg/kg of total cPAHs.
- ▶ cPAHs exhibit very low aqueous solubilities and are likely to be relatively immobile in the Shallow Aquifer given its high organic carbon content. This is demonstrated by the absence of PAHs in groundwaters downgradient from the charcoal area.

3.3.2 OFA/Pennwalt Area Surface Water

3.3.2.1 Copper, Lead, and Arsenic Cleanup Levels

The cleanup objective for the metals detected in the OFA Ditch is to reduce the amount of slag particulates in surface water runoff from the OFA/Pennwalt Area. The cleanup goal is to meet freshwater aquatic criteria in site surface water discharges (See Table 3-1). The freshwater criteria are appropriate because the OFA/Pennwalt Area runoff collects in the OFA Ditch which is above tide level, contains freshwater, and has the potential to support freshwater organisms. Under MTCA, the point of compliance for surface water cleanup is at the point at which the contaminant discharges to the water body. Future site runoff will also discharge to freshwater ditches and drainages and this point of compliance will be at the stormwater drains.

Subsequent discharge of site waters is to estuarine water bodies where the waters are mixed with the storm water and tide waters prior to ultimate release to marine water bodies. The data indicate current site discharges will meet the marine aquatic life criteria in the estuarine areas.

The cleanup level for copper and lead are presented as a function of the hardness of the surface water. Hardness is a measure of the amount of bicarbonate in the water. Studies have shown the toxicity of copper and other slag-related metals such as lead are related to the bicarbonate (expressed as hardness) in the water (EPA, 440/5-86-001), hence the cleanup levels are based on hardness as presented in Table 3-1.

3.4 Location- and Action-Specific ARARs

The potential location- and action-specific ARARs considered in evaluating the cleanup levels and alternatives for the Blair Backup property are presented in Appendix F. The location-specific ARARs address the concentration of hazardous substances or the conduct of activities solely because they occur in the Port of Tacoma, Commencement Bay area. The action-specific ARARs define acceptable management practices specific to certain kinds of activities or technologies that could occur during the implementation of the potential cleanup alternative(s). In Appendix F, these ARARS are evaluated relative to the material of concern and whether the alternative includes removal of the material off the site or inclusion into an on site alternative. Each Alternative's compliance with ARARs is summarized in the evaluation discussion of each alternative.

3.5 Cleanup Objectives Addressed through Analysis of Alternatives

The work completed through the Final Investigation Report and supplemental studies conducted for this Alternatives Analysis concluded that the area of cPAH contamination is confined within a small portion of the slag-contaminated soil area of the OFA/Pennwalt Area. As such, it is appropriate to address remediation of this area within the context of the overall remediation of the OFA/Pennwalt Area.

Based on this we have divided the Analysis of Alternatives into two components. The first is an evaluation of alternatives for remediation of metals contamination associated with slag in the OFA/Pennwalt Area. We present this discussion in Section 4. Subsequently we evaluate alternatives for remediation of cPAH-contaminated soil in Section 5. This is possible since the range of alternatives identified for the slag-contaminated soil are congruous with the range of alternatives identified for the cPAH-contaminated soils. As will be seen subsequently, each

alternative discussed in Section 4 can be constructed integrally with any alternative discussed in Section 5.

3.6 Incorporation of Additional Media into Site Cleanup Alternatives

Excavation of sandblast grit and soil within the North Site Area was completed as part of a voluntary cleanup action. The volume of excavated sandblast material was far more extensive than originally anticipated. Additionally, disposal options diminished as waste characterization analyses indicated removal from the site would potentially characterize the grit as a Dangerous Waste (See Appendix F).

For these reasons, the disposition of approximately 1,000 cubic yards of sandblast waste was added to the evaluation of alternatives. The cleanup objective for disposal of the sandblast grit-contaminated soil is to protect groundwater quality by preventing metals leaching from the grit. Section 6.0 further discusses the cleanup objections and evaluation of alternatives for the sandblast grit-contaminated soil and a summary of the test data collected from the excavation of the grit and soil is presented in Appendix H.

In the process of completing alternative analyses for the Blair Backup and Blair Waterway properties, the desirability and congruity of a combined cleanup alternative became apparent. The combined alternative includes moving approximately 18,000 cubic yards of Asarco slag and soil from the Blair Waterway property onto the Blair Backup property and incorporation into the OFA/Pennwalt Area slag-contaminated soil remediation.

The soil and surface water cleanup objectives for a combined properties alternative will be the same as those defined for the OFA/Pennwalt Area slag (which includes a small volume of Asarco slag). However, the additional quantities of Asarco slag will require that the cleanup objectives also includes protection of groundwater quality. The groundwater protection standard will be that no statistically significant increase in metals occur following site cleanup. Section 8 presents the evaluation of this combined alternative.

Table 3-1 -Cleanup Objectives

Chemical	Cleanup Goal	OFA/Pennwalt Soil Cleanup Concentration in mg/kg ^(a)	OFA/Pennwalt Surface Water Cleanup Level in mg/L ^(d)
Arsenic	Prevent direct contact/ingestion of soils above and prevent transport of slag particulates in surface water discharges	200 (b)	0.190
Chromium	Prevent inhalation of dust above	500 (c)	NA
Total Carcinogenic PAHs	Prevent direct contact/ingestion of soils above	20 (b)	NA
Total Recoverable Copper	Prevent transport of slag particulates in surface water discharges	NA	$e(0.8545 [\ln(\text{hardness})]-1.465)$
Total Recoverable Lead	Prevent transport of slag particulates in surface water discharges	NA	$e(1.273 [\ln(\text{hardness})]-4.705)$

Notes:

- (a) Based on MTCA Method Cleanup Levels - Industrial Soil
- (b) Based on direct soil contact risks (1×10^{-5} , lifetime cancer risk)
- (c) Based on potential inhalation risks (1×10^{-5} , lifetime cancer risks)
- (d) Chronic freshwater aquatic criteria (Clean Water Act Water Quality Standards 40 CFR 131) for copper and lead cleanup levels is based on hardness in mg/L of site surface water.
- NA Not applicable - no cleanup required.

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4.0 EVALUATION OF ALTERNATIVES FOR OFA/PENNWALT AREA SLAG/SOIL

4.1 Introduction

This section evaluates cleanup alternatives for the soil within the OFA/Pennwalt Area which has been contaminated with a mixture of OFA slag and Asarco slag.

Approximately 80,000 cy of slag/soil material are present in the OFA/Pennwalt Area. Figure 4-1 shows the existing topography of the site as well as the extent of slag/soil. The site is generally higher on the western and northern edges (roughly elevation 18 to 19 feet). In the southeastern portion of the site is the lowest grade with elevations of 10 feet or less. A ditch has been cut through this low area to other portions of the site for drainage.

The slag/soil extent covers roughly 12 to 13 acres of the site. As discussed in Appendix D the soil/slag extent estimates are based on test pits completed in the area. Appendix D also describes in detail the estimated grain size distribution of this soil/slag material. Laboratory analysis of representative samples from the test pits indicate the following constituents of the soil/slag material (by total weight):

- ▶ 1 to 2 percent miscellaneous debris;
- ▶ 8 to 10 percent organics;
- ▶ 30 to 35 percent OFA slag;
- ▶ 51 to 60 percent soil;
- ▶ 1 to 2 percent Asarco slag.

The soil is typically a slightly silty to silty, gravelly sand to sandy gravel with cobbles. The organics consist primarily of wood chips. Miscellaneous debris includes concrete rubble, lumber, metal, etc.

As described in Appendix D, the slag/soil material typically is found at the ground surface and is on average three to four feet thick with thicknesses of up to eight feet in some areas.

It is important to note that the material from the OFA/Pennwalt Area will be referred to as the "OFA Slag/Soil" in order to differentiate it from the term "Asarco Slag" material described as "Blair Waterway Slag" from the Blair Waterway property.

This section also takes into account the evaluation of cleanup alternatives for the OFA Ditch Surface Water. It is important to realize that the OFA Ditch is most likely an indication of surface water issues across the OFA/Pennwalt Area. The

ditch area has been concentrated on because it has typically been the only distinguished surface water area on the site from which adequate surface water samples could be collected. Our analysis of alternatives therefore reflects alternatives which will address the broader issue of overall site surface water runoff.

4.2 *Cleanup Objectives—Prevent Human Contact with Slag and Prevent Surface Water Transport of Slag*

As stated in Section 3.0, the cleanup objectives for the OFA/Pennwalt Area of the Blair Backup property are based on a review of the chemicals and media identified for cleanup as well as ARARs and other methods used to determine appropriate cleanup levels.

The cleanup objectives for the soil/slag in the OFA/Pennwalt Area are:

- ▶ Prevent human contact (ingestion, direct contact, and inhalation) of soils with elevated concentrations of chromium and arsenic;
- ▶ Prevent migration of slag particulates in runoff from the site.

4.3 *Identification and Screening of Technology Types and Process Options*

The EPA has grouped remedial technologies into nine categories which correspond to general site problems. The categories include:

- ▶ Surface Water Controls
- ▶ Air Pollution Controls
- ▶ On-Site and Off-Site Disposal of Waste and Soil
- ▶ *In Situ* Treatment Measures
- ▶ Direct Waste Treatment (i.e., separation, solidification, and stabilization)
- ▶ Institutional Controls

As part of reviewing these technologies we considered all technologies which might be applicable. The next step in the process is to screen out those potential technologies which are not most applicable to the contaminants and media of concern. To do this we used three basic criteria:

- ▶ Effectiveness
- ▶ Implementability
- ▶ Cost

Using these criteria, we screened out those technologies which were not considered to be applicable to the issues or contaminants or media of concern at the site. This would include such technologies as thermal treatment or incineration which is ineffective for destruction of elemental metals. Technologies such as bioremediation were also screened because of the inorganic nature of the contamination.

4.4 Development of Remedial Alternatives

The next step in the screening process was to formulate the alternatives that potentially meet the cleanup objectives. In this process we combine all of the applicable technologies in all possible variations. We considered nine applicable technologies. There are many possible ways that these may be combined. To simplify things, we have grouped the technologies into logically similar categories.

- ▶ **Universal.** This category consists of technologies used within any alternative. For this case the only universal technology is **Site Grading**.
- ▶ **Primary.** This category consists of the main thrust of the cleanup alternative. These technologies for this case include **Filling and Excavation**.
- ▶ **Secondary.** This category of technologies can only be used in conjunction with other technologies and for this case include: **Landfilling, Separation, Solidification, Stabilization, and Erosion/Dust Control**.

We then formulated all the reasonable alternatives. Some of the resulting alternatives were illogical and eliminated by inspection. This procedure resulted in the seven possible applicable alternatives which are discussed in detail in the following sections.

4.4.1 Alternative 1 - No Action

This alternative is required by law to be evaluated and serves as a baseline for comparison of other alternatives. This alternative represents the situation if no further cleanup activities were conducted.

This alternative would leave the OFA slag/soil exposed across the entire site. Institutional controls would be implemented to reduce exposure to the material left on site. These institutional controls would need to be formulated such that access to the site was severely restricted.

These institutional controls would include:

- ▶ Restricting use of groundwater from the Shallow and Intermediate Aquifers at the site for use as drinking water;
- ▶ Require that health and safety plans and provisions be observed during future subsurface work at the site that may expose workers to the slag-contaminated soil and require that personnel involved with subsurface work should be health and safety trained; and
- ▶ Provide appropriate notification to current and future owners and tenants as well as persons engaged in pertinent on-site activities.

Monitoring of surface water runoff and groundwater quality would also be required.

4.4.2 Alternative 2 - Site Grading

This alternative consists of grading (cutting and filling) the site to achieve more uniform elevation and to improve site drainage. Earth moving equipment would cut material from the site's west side. This cut material will be placed and compacted in the low areas of the site's east end. As can be seen on Figure 4-1 the area of slag-contaminated soil is irregular. From a constructibility standpoint it will be more appropriate to extend the cleanup area to the entire 17 acres of this portion of the site (Refer to Figure 4-2.) After site grading the site will be at an elevation of approximately 15 to 16 feet. Site grading will entail developing a ditch system to promote site runoff and to prevent site run-on. After grading, erosion/dust control measures will be established, including vegetation and silt fences.

The on-site surficial bark and wood chips will be spread uniformly across the site after initial grading. We estimate a thickness of 2 to 3 inches over the 17 acres. Spreading the bark across the site will minimize geotechnical impacts of the material and eliminate need for off-site transport and disposal.

Institutional controls will consist of restrictions on use of groundwater, requirements for health and safety provisions for subsurface work, and notification requirements as discussed earlier.

Surface water monitoring would be required.

4.4.3 Alternative 3 - Sand and Gravel Cover

This alternative will first involve cutting and filling of the site as discussed in Section 4.4.2.

After completion of the site grading and distribution of wood debris, a two-foot-thick sand and gravel cap will be placed and compacted over the entire 17 acres as shown on Figures 4-2 and 4-3. The sand and gravel will be brought to the site by truck, spread with a bulldozer or grader, and compacted with vibratory rollers. The site will be graded to induce channelized flow in a ditch system. Ditches will be protected from erosion. Erosion/dust control measures will be established.

The criteria for selection of a two-foot thickness is twofold. First, two feet of well compacted clean sand and gravel will preclude unintentional contact with the underlying slag-contaminated soil. This amount of well-compacted sand and gravel fill provides a high strength material which is extremely difficult to penetrate without the use of power equipment. Second, two feet of compacted fill is geotechnically appropriate in that it will provide good subgrade support for subsequently placed high capacity pavement sections, and it will allow for reasonable site access and site use in an unpaved condition.

The sand and gravel layer will filter and confine slag particulates that might be potentially carried in surface water runoff. The site will be graded to induce channelized flow in a ditch system. Ditches will be protected from erosion.

The final elevation of the cap will allow easy access to Taylor Way.

Institutional controls will consist of restrictions on use of groundwater, requirements for health and safety provisions for subsurface work, and notification requirements as discussed earlier.

Surface water monitoring would be included.

4.4.4 Alternative 4 - Low Permeability Soil Cover

This alternative will first involve cutting and filling of the site as discussed in Section 4.4.2.

After completion of site grading and distribution of wood debris, a two-foot-thick low permeable soil cover will be placed and compacted over the site as shown on Figures 4-2 and 4-4. The material will be a till fill soil or other fill of low

permeability. The till fill will be brought to the site by truck, spread with a bulldozer or grader, and compacted with sheepsfoot or smooth dead rollers. The site will be graded to induce channelized flow in a ditch system. Ditches will be protected from erosion. Erosion/dust control measures will be established. This alternative is essentially the same as Alternative 3 with the exception that a low permeability soil will be used instead of well-graded clean sand and gravel.

The final elevation of the cap will allow easy access to Taylor Way.

Institutional controls will consist of restrictions on use of groundwater; requirements for health and safety provisions for subsurface work, and notification requirements as discussed earlier.

Surface water monitoring would be included.

4.4.5 Alternative 5 - Sand and Gravel and Asphalt Pavement Cover

This alternative will first involve cutting and filling of the site as discussed in Section 4.4.2.

Next the site will be filled with approximately 18 inches of well-compacted sand and gravel fill as discussed earlier for Alternative 3. Then a pavement section consisting of two inches of class E asphalt pavement over four inches of crushed rock will be placed and compacted over the site as shown on Figures 4-2 and 4-5. The crushed rock and asphalt will be brought to the site by truck and spread and compacted with standard paving equipment. The site will include a catch basin and culvert system connected to the Taylor Way culvert.

The final elevation of the pavement will allow easy access to Taylor Way.

Institutional controls will consist of restrictions on use of groundwater, requirements for health and safety provisions for subsurface work, and notification requirements as discussed earlier.

Surface water monitoring would be included.

4.4.6 Alternative 6 - Excavation and Landfilling

This alternative will first consist of excavating the soil/slag material over the 13-acre area. The soil/slag material will be excavated with a trackhoe using a "cut and cover" technique whereby areas of excavation are immediately backfilled as the excavation advances. The trackhoe will begin at one end of the site and will excavate a wide trench. The trackhoe will load trucks as it excavates. The trucks would haul the soil/slag material to an approved land disposal area. As the trench is advanced down the site, the trench is backfilled with select fill, typically a well-graded sand and gravel. The fill will be brought to the site by truck, spread by bulldozer or grader, and compacted with vibratory rollers. As the site is overexcavated and backfilled the final elevation of the backfill material will be graded to drain the site to an elevation of 15 to 16 feet. Erosion and dust control measures will be established. The material would be disposed of at an approved waste disposal facility. We anticipate that most of the material could be disposed of at a permitted solid waste facility while portions could require disposal at an approved Dangerous Waste facility.

Note: For purposes of this Analysis of Alternatives we have assumed that the vast majority of the material, if not **all** of the material would not be considered RCRA Hazardous Waste or Washington State Dangerous Waste.

Depending on the depth of slag at any given point across the site some dewatering may be required during excavation to facilitate access to the material. Depending on the final destination of the material it may be necessary to stockpile the material on the site to allow it to drain prior to transport.

Institutional controls will not be required.

No monitoring will be necessary.

4.4.7 Alternative 7 - Stabilization

This alternative will first consist of excavating the soil/slag material over the 13-acre area. The soil/slag material will be excavated with a trackhoe using a "cut and cover" technique whereby areas of excavation are immediately backfilled as the excavation advances. The trackhoe will begin at one end of the site and will excavate a wide trench. The trackhoe will load trucks as it excavates. The trucks would haul the soil/slag material to an area of the site setup with a solidification/stabilization plant. Figure 4-6 illustrates the procedure.

The solidification/stabilization process will consist of the addition of Portland cement and other materials (based on treatability testing) to the soil/slag material. Cement would be added in the range of 3 to 12 percent in order to create a compacted soil-cement. The soil would probably require screening and crushing of large particles; the crushed particles would be added back to the soil mix. The processed mix of soil and cement would be designed to provide relatively low permeability, good strength, compactibility, and adequate pH control. Additives may be added, if necessary, to reduce shrinkage upon curing. Detailed bench-scale and pilot-scale treatability testing would be required prior to implement this alternative.

As the trench is advanced down the site, the trench is backfilled with the stabilized soil/slag material via cement or dump trucks. Compaction of each lift would be performed. As the site is overexcavated and backfilled the final elevation of the backfill material will be graded to drain the site. Erosion and dust control would be established.

Institutional controls will consist of restrictions on use of groundwater, requirements for health and safety provisions for subsurface work, and notification requirements as discussed earlier.

Surface water monitoring would be included.

4.5 *Evaluation Criteria for Alternatives*

We developed the criteria for evaluation based on the EPA's guidance for conducting feasibility studies under CERCLA. We have slightly modified our criteria to include the following seven:

- ▶ **Overall Protection of Human Health and the Environment.** This criteria assesses the extent to which the identified risks to health and the environment are reduced, eliminated, or controlled. It also contemplates the extent of future exposures to contaminants.
- ▶ **Compliance with ARARs.** This criteria examines the extent to which chemical-, location-, and action-specific ARARs can be met. Appendix F presents a comprehensive discussion of ARARs for the cleanup alternatives.
- ▶ **Implementability.** Implementability considers technical feasibility, difficulty in obtaining administrative approvals within a reasonable time frame, and availability of required services and materials.

- ▶ **Short-Term Effectiveness.** Short-term effectiveness evaluates the level of risk to the community until the cleanup is completed, and level of risk to cleanup workers.
- ▶ **Long-Term Effectiveness.** Long-term effectiveness evaluates to what extent the technologies will work as well as expected over a long period of time.
- ▶ **Reduction of Toxicity, Mobility, or Volume through Treatment**
- ▶ **Cost**

In addition to the seven criteria cited above, the Puyallup Settlement Agreement specifies that the selected alternative must leave the site reasonably usable for commercial and industrial use. The Puyallup Settlement Agreement also indicates that the cleanup action shall meet applicable state and federal standards and furthermore states that the Puyallup Tribe shall support cost-effective solutions. Therefore, we have included **Effects on Site Development** as an additional evaluation criteria.

4.6 Evaluation of Alternatives

This section presents a discussion of the seven alternatives considered for remediating the slag concerns at Blair Backup property.

4.6.1 Alternative 1 - No Action

This alternative simply consists of maintaining the baseline condition.

The key considerations of this alternative are:

- ▶ Low cost
- ▶ Easily implemented
- ▶ The alternative does not substantially limit contact with the slag-contaminated soils without implementation of severe institutional controls to restrict access.
- ▶ The alternative does not limit particulates in site runoff.
- ▶ The slag-contaminated soil remains on site.

Overall Protection of Human Health and the Environment. This alternative does not preclude direct contact with the slag-contaminated soil nor does it preclude particulate migration in surface runoff. It therefore does not meet the cleanup objectives for slag-contaminated soil and is not considered protective of human health and the environment.

Compliance with ARARs. The chemical-specific ARARs for the soil and surface water cleanup are not met with this alternative. Soil concentrations may still exceed the cleanup levels. Action-specific or location-specific ARARs would not be triggered under this alternative.

Because this alternative does not protect human health and the environment, nor comply with cleanup levels, it will not be considered further.

4.6.2 Alternative 2 - Site Grading

This alternative consists of grading the site to drain and provision of erosion and dust control measures.

The key considerations for this alternative are:

- ▶ Low cost.
- ▶ Easily implemented.
- ▶ The site is essentially prepared for future development.
- ▶ The alternative does not substantially limit contact with the slag-contaminated soils without implementation of severe institutional controls to restrict access.
- ▶ The alternative does not control the transport of slag particulates in site runoff.
- ▶ The slag-contaminated soil remains on site.

Overall Protection of Human Health and the Environment. This alternative does not preclude direct contact with the slag-contaminated soil nor does it preclude particulate migration in surface runoff. It therefore does not meet the cleanup objectives for slag-contaminated soil and is not considered protective of human health and the environment.

Compliance with ARARs. ARARs associated with the remedial alternative include MTCA Method A industrial cleanup levels for arsenic and chromium and MTCA Method B fresh water cleanup level for copper, arsenic, and lead. These chemical-specific ARARs are not met with this alternative because exposures to metals exceeding the cleanup levels still exist. Action-specific or location-specific ARARs would not be triggered under this alternative.

Because this alternative does not protect human health and the environment, nor comply with cleanup standards, it will not be considered further.

4.6.3 Alternative 3 - Sand and Gravel Cover

This alternative consists of grading the site followed by a placement of a protective cover of two feet of select sand and gravel cover material.

The key considerations for this alternative are:

- ▶ Low cost.
- ▶ Easily implemented.
- ▶ Site is prepared for subsequent development.
- ▶ Precludes contact with slag-contaminated soils and prevents particulates in runoff. It therefore meets cleanup objectives and is protective of human health and the environment.
- ▶ The slag-contaminated soil remains on site.
- ▶ Some institutional controls still required.

Overall Protection of Human Health and the Environment. This alternative precludes direct contact, ingestion, and inhalation of the slag-contaminated soil. It also will preclude migration of slag particulates from the site. As such it meets the cleanup objectives for the site and is therefore protective of human health and the environment.

Compliance with ARARs. Chemical-specific ARARs associated with the remedial alternative include MTCA Method A industrial cleanup levels for arsenic and chromium and MTCA Method B fresh water level for copper. The cleanup requirement to protect against direct contact with arsenic, inhalation of chromium

and surface water migration of copper is met with this alternative because a two-foot protective buffer cover of sand and gravel is placed over the soil/slag. This cover will minimize human contact with the soil/slag.

There are no action- and location-specific ARARs in as much as material is not removed from the area and groundwater protection is not a cleanup objective.

Implementability. This alternative will use standard earthmoving equipment for site grading, and sand and gravel importing, placing, and compacting. Because standard equipment and methods will be used, minimal difficulties or unknowns are associated with construction. Additional work in the future may include maintenance of ditch system, maintaining the minimum two-foot thickness of material, and repairing erosion/dust control system.

This technology is well established and should not require special review. Required services and materials should be readily available.

Short-Term Effectiveness. The alternative will take a relatively short time to implement. The risks to the workers during construction are the same as the risks that the alternative is intended to mitigate. Therefore the overall risk to workers during construction is low provided the institutional controls discussed for this alternative are implemented.

Long-Term Effectiveness. The proposed technologies are simple and reliable. Given proper and simple maintenance the alternative will perform as well in the future as it will immediately following construction. Maintenance technologies are also simple and effective.

Reduction of Toxicity, Mobility, or Volume through Treatment. This alternative does not reduce toxicity, mobility, or volume of arsenic and chromium through treatment.

Cost. The cost is approximately \$896,000. Refer to Appendix G for a more detailed cost analysis.

Effects on Site Development. With this alternative the site can be used immediately. It raises the grade of the site to be commensurate with the adjacent access roadway

as well as provides drainage for future and present development. Placement of sand and gravel fill will provide an excellent subgrade for subsequent paving operations. Repair and maintenance of the cover will be simple and cost-effective.

4.6.4 Alternative 4 - Low Permeability Soil Cover

This alternative consists of grading the site followed by placement of a two-foot-thick protective cover of low permeability soil.

The key considerations for this alternative are:

- ▶ Low cost.
- ▶ Easily implemented.
- ▶ Site is prepared for subsequent development.
- ▶ Precludes contact with slag-contaminated soils and prevents particulates in runoff. It therefore meets cleanup objectives and is protective of human health and the environment.
- ▶ The slag-contaminated soil remains on site.
- ▶ Some institutional controls still required.
- ▶ Long-term maintenance of the cover will be more difficult since it consists of material which is easily disturbed during the wetter times of the year.

Overall Protection of Human Health and the Environment. This alternative precludes direct contact, ingestion, and inhalation of the slag-contaminated soil. This is because the soil/slag is secured beneath the low permeable soil cover on the site. It also will preclude migration of slag particulates from the site. As such it meets the cleanup objectives for the site and is therefore protective of human health and the environment.

Compliance with ARARs. Chemical-specific ARARs associated with the remedial alternative include MTCA Method A industrial cleanup levels for arsenic and chromium and MTCA Method B fresh water level for copper. The cleanup requirement to protect against direct contact with arsenic, inhalation of chromium and surface water migration of copper is met with this alternative because a

two-foot protective buffer cover of low permeability soil is placed over the soil/slag. This cover will minimize human contact with the soil/slag.

There are no action- and location-specific ARARs in as much as material is not removed from the area and groundwater protection is not a cleanup objective.

Implementability. This alternative will use standard earthmoving equipment for site grading, low permeability fill importing, placing and compacting. Because standard equipment and methods will be used, minimal difficulties or unknowns are associated with construction. Additional work in the future may include maintenance of ditch system, maintaining the minimum two-foot thickness of material and repairing erosion/dust control system.

This technology is well established and should not require special review. Required services and materials should be readily available.

Short-Term Effectiveness. The alternative will take a relatively short time to implement. The risks to the workers during construction are the same as the risks that the alternative is intended to mitigate. Therefore the overall risk to workers during construction is low provided the institutional controls discussed for this alternative are implemented.

Long-Term Effectiveness. Proposed technologies are simple and reliable. In order to achieve low permeability the materials used as fill will have a high percentage of silt and clay. To maintain the material in a low permeability condition it must be maintained in a densely compacted state. Given the wet conditions of Western Washington during the winter and spring seasons, the low permeability cover will be highly susceptible to disturbance due to high moisture conditions. Maintenance and repairs to the cover would therefore be difficult.

Reduction of Toxicity, Mobility, or Volume through Treatment. This alternative does not reduce toxicity, mobility, or volume of arsenic and chromium through treatment.

Cost. The cost is approximately \$1,054,900. Refer to Appendix G for a more detailed cost analysis.

Effects on Site Development. With this alternative the site can be used immediately. It raises the grade of the site to be commensurate with the adjacent access roadway as well as provides drainage for future and present development. Placement of

compacted fill material will provide good subgrade for subsequent paving operations. Repair and maintenance of the cover will be more difficult because of the potential for disturbance and loss of strength of the material.

4.6.5 Alternative 5 - Sand and Gravel and Asphalt Pavement Cover

This alternative consists of grading the site, placement of 18 inches of select sand and gravel, and placement of a moderate duty pavement section consisting of two inches of asphaltic concrete over four inches of crushed rock base course material.

The key considerations for this alternative are:

- ▶ Moderate cost.
- ▶ Easily implemented.
- ▶ Precludes contact with slag-contaminated soils and prevents particulates in runoff. It therefore meets cleanup objectives and is protective of human health and the environment.
- ▶ Site is prepared for subsequent development.
- ▶ The slag-contaminated soil remains on site.
- ▶ Some institutional controls still required.
- ▶ Pavement will require a higher degree of maintenance than, say, sand and gravel fill cover.

Overall Protection of Human Health and the Environment. This alternative precludes direct contact, ingestion, and inhalation of the slag-contaminated soil. It also will preclude migration of slag particulates from the site. As such it meets the cleanup objectives for the site and is therefore protective of human health and the environment.

Compliance with ARARs. Chemical-specific ARARs associated with the remedial alternative include MTCA Method A industrial cleanup levels for arsenic and chromium and MTCA Method B fresh water level for copper. The cleanup requirement to protect against direct contact with arsenic, inhalation of chromium, and surface water migration of copper is met with this alternative because a 18-inch

protective buffer cover of sand and gravel, and pavement are placed over the soil/slag. This cover will minimize human contact with the soil/slag.

There are no action- and location-specific ARARs in as much as material is not removed from the area and groundwater protection is not a cleanup objective.

Implementability. This alternative will use standard earthmoving equipment for site grading, sand and gravel importing, placing, and compacting; and paving. Because standard equipment and methods will be used, minimal difficulties or unknowns are associated with construction. Additional work in the future may include maintenance of ditch system, maintaining the minimum two-foot thickness of material and repairing erosion/dust control system.

This technology is well established and should not require special review. Required services and materials should be readily available.

Short-Term Effectiveness. The alternative will take a relatively short time to implement. The risks to the workers during construction are the same as the risks that the alternative is intended to mitigate. Therefore the overall risk to workers during construction is low provided the institutional controls discussed for this alternative are implemented.

Long-Term Effectiveness. The technologies which will be used are simple and reliable. Given proper and simple maintenance the alternative will perform as well in the future as it will immediately following construction. Maintenance technologies are also simple and effective. Additional work in the future may include maintenance of catch basins, patching of cut pavement, and pavement overlays.

Reduction of Toxicity, Mobility, or Volume through Treatment. This alternative does not reduce toxicity, mobility, or volume of arsenic and chromium.

Cost. Cost is approximately \$1,453,300. Refer to Appendix G for a more detailed cost analysis.

Effects on Site Development. With this alternative the site can be used immediately. It raises the grade of the site to be commensurate with the adjacent access roadway as well as provides drainage for future and present development. Placement of sand and gravel fill and the pavement will provide an excellent subgrade for subsequent

filling and paving operations. Repair and maintenance of the cover will be simple and cost-effective.

4.6.6 Alternative 6 - Excavation and Landfilling

This alternative consists of overexcavation of the OFA slag/soil and transportation of the material to a suitable landfill facility. The site will then be backfilled to its current elevation.

The key considerations for alternative are:

- ▶ Precludes contact with slag-contaminated soils and prevents particulates in runoff. It therefore meets cleanup objectives and is protective of human health and the environment.
- ▶ The material is removed from the property which precludes need for future cleanup actions.
- ▶ Site is prepared for subsequent development.
- ▶ Institutional controls for the site will not be required.
- ▶ Extremely high cost.
- ▶ Given the high volume of material it may be difficult to find a suitable disposal site for the material (i.e., potentially very difficult to implement).

Overall Protection of Human Health and the Environment. This alternative precludes direct contact, ingestion, and inhalation of the slag-contaminated soil. It also will preclude migration of slag particulates from the site. As such it meets the cleanup objectives for the site and is therefore protective of human health and the environment.

Compliance with ARARs. Chemical-specific ARARs associated with the remedial alternative include MTCA Method A industrial cleanup levels for arsenic and chromium and MTCA Method B fresh water level for copper. The arsenic and chromium ARAR is met with this alternative because the material is removed from the site.

Action-specific provisions of the Washington State Dangerous Waste Regulations concerning transportation, storage, and disposal of the waste may apply. These

ARARs will determine the appropriate disposal method and location for the excavated material.

Implementability. This alternative will use standard earthmoving equipment for site excavation and grading, and sand and gravel importing, placing, and compacting. Because standard equipment and methods will be used, minimal difficulties or unknowns are associated with construction. No long-term maintenance will be required.

This technology is well established. Given the high volume of the material and potential waste designation it may not be possible to dispose of the material at an off-site location. Required services and materials should be readily available. If large amounts of dewatering are required it may not be technically feasible to handle the water using storage tanks for subsequent treatment (which could be required). It may also not be possible to dispose of the water in local treatment facilities.

Short-Term Effectiveness. The alternative will take a relatively short time to implement. The risks to the workers during construction are the same as the risks that the alternative is intended to mitigate. Therefore the overall risk to workers during construction is low provided the institutional controls discussed for this alternative are implemented.

Long-Term Effectiveness. The technologies which will be used are simple and reliable.

Reduction of Toxicity, Mobility, or Volume through Treatment. This alternative does not reduce toxicity, mobility, or volume of arsenic and chromium.

Cost. Cost is approximately \$17,972,700. This cost estimate assumes that a portion of the material could be disposed of in a solid waste landfill and that a portion would need to be disposed of in a Dangerous Waste landfill. This is based on the OFA Slag being considered a solid waste and the Asarco slag being regard as a dangerous waste. Refer to Appendix G for a more detailed cost analysis.

Effects on Site Development. There will be no adverse effects on site development because the contaminants will be removed from the site and no maintenance is required.

4.6.7 Alternative 7 - Stabilization

This alternative consists of overexcavation of the OFA slag/soil, followed by cement stabilization of the material, and return of the stabilized material to the excavation.

The key considerations for this alternative are:

- ▶ Precludes contact with slag-contaminated soils and prevents particulates in runoff.
- ▶ Institutional controls for the site will still be required.
- ▶ Site is prepared for subsequent development.
- ▶ Extremely high cost.
- ▶ Given the low levels of metals in the soil the effectiveness of the technology is limited
- ▶ The slag-contaminated soil remains on site.
- ▶ Some institutional controls still required.

Overall Protection of Human Health and the Environment. This alternative precludes direct contact, ingestion, and inhalation of the slag-contaminated soil. It also will preclude migration of slag particulates from the site. As such it meets the cleanup objectives for the site and is therefore protective of human health and the environment.

Compliance with ARARs. Chemical-specific ARARs associated with the remedial alternative include MTCA Method A industrial cleanup levels for arsenic and chromium and MTCA Method B fresh water level for copper. The cleanup requirement to protect against direct contact with arsenic, inhalation of chromium and surface water migration of copper is met with this alternative because the material is consolidated within a stabilized monolithic mass.

There are no action- and location-specific ARARs in as much as material is not removed from the area and groundwater protection is not a cleanup objective.

Implementability. Difficulties and/or uncertainties may be encountered since a large area will be excavated. High groundwater and potential unexpected conditions can

also make excavation difficult. Because of the organics content of soil/slag material in some areas it may be very difficult to stabilize/solidify material. Additional overexcavation may be required if verification testing indicates material still present. If large amounts of dewatering are required it may not be technically feasible to handle the water using storage tanks for subsequent treatment. It may also not be possible to dispose of the water in local treatment facilities.

Bench- and pilot-scale treatability studies as well as test sections prior to work will be required to show that the process can be performed as planned. Establishing a workable procedure may take time.

Short-Term Effectiveness. The alternative will take a longer time to implement. The risks to the workers during construction are the same as the risks that the alternative is intended to mitigate. Therefore the overall risk to workers during construction is low provided the institutional controls discussed for this alternative are implemented.

Long-Term Effectiveness. The technologies which will be used are simple. The reliability of cement stabilization over the long-term is not as well determined as using natural earthen materials. The effectiveness of the solution may deteriorate over time.

Reduction of Toxicity, Mobility, or Volume through Treatment. The mobility of the contaminant is reduced at the site and overall. The toxicity and volume of the material is not reduced.

Cost. Cost is approximately \$9,745,500. Refer to Appendix G for a more detailed cost analysis.

Effects on Site Development. There are potential adverse impacts on site development due to the presence of stabilized material which will need to be excavated for placement of utilities and foundations. Heavier equipment will be required for this type of site work. The stabilized material should, however, provide excellent foundation support.

4.7 Comparative Analysis of Alternatives

Briefly as stated before the seven alternatives are:

1. No Action
2. Site Grading

3. Sand and Gravel Cover
4. Low Permeability Soil Cover
5. Sand and Gravel and Asphalt Pavement Cover
6. Excavation and Landfilling
7. Stabilization

As indicated previously Alternatives 1 and 2 have been eliminated from further discussion because of a failure to demonstrate protectiveness of human health and the environment. These will not be carried forward for comparative analysis.

Table 4-1 presents a summary of the comparative analyses for these alternatives.

4.7.1 Overall Protection

Each of the remaining alternatives is protective of human health and the environment.

4.7.2 Compliance with ARARs

The remaining alternatives either cover, stabilize, or remove the soil/slag material, limiting human contact and reducing slag particulates in surface water. Therefore, they meet the arsenic and chromium ARARs.

There are no action- or location-specific ARARs for those alternatives which leave the material in place. State Dangerous Waste Regulations may be invoked if the material were to be removed from the site for Alternative 6.

4.7.3 Implementability

Alternatives 3 and 5 are the most easily implemented of the alternatives. Alternatives 6 and 7 require deep excavation which will be difficult with the high groundwater table. Adverse schedule impacts for Alternative 6 would also center around the fact that landfills may not be able to accept the large volume of material over a short-term. Alternative 7 also requires treating the soil, which will add to scheduling problems, because detailed bench- and pilot-scale treatability studies would be necessary and the actual stabilization of this amount of material would be a lengthy process. Alternative 4 would require working with till fill material which is problematic to work with in wet weather conditions and would likely have an adverse schedule impact.

4.7.4 Short-Term Effectiveness

Short-term risks to workers and the community can be adequately controlled through the use of institutional controls discussed previously. Greater exposure to workers will occur for Alternatives 6 and 7 where all of the material will need to be handled.

4.7.5 Long-Term Effectiveness

Removal of the slag-contaminated soil from the site (Alternative 6) will have the greatest long-term effectiveness because the material will be removed from the site and no maintenance will be required. Alternatives 3 and 5 (Sand and Gravel Cover and Pavement, respectively) will also be effective in the long-term because of the simplicity of construction, the ability of the material to stand up to the long-term use of the site, and the relatively minor maintenance required. The use of a low permeability fill cover (Alternative 4) has a lower long-term effectiveness because of its susceptibility to disturbance and somewhat greater maintenance requirements.

The potential failure of the system is low for all the alternatives with Alternative 7 having a slightly higher failure potential. This is because of the uncertainty of treating the soil/slag material. The magnitude of risk associated with system failure of all seven alternatives is the same as the magnitude of the present risk.

4.7.6 Reduction of Toxicity, Mobility, or Volume through Treatment

None of the alternatives directly reduces toxicity, mobility, or volume of the soil/slag material, with the exception of Alternative 7 which does reduce the mobility of the contaminants. Direct treatment of the contaminants does not occur in any of the alternatives except Alternative 7.

4.7.7 Cost

The following is a summary of cost comparisons.

Alternative	Estimated Total Cost
1 No Action	\$2,800
2 Site Grading	\$151,500
3 Sand and Gravel Cover	\$896,000
4 Low Permeability Soil Cover	\$1,054,900
5 Sand and Gravel and Asphalt Pavement Cover	\$1,453,300
6 Excavation and Landfilling	\$17,972,700
7 Stabilization	\$9,745,500

4.7.8 Effects on Site Development

All alternatives are compatible with future site development. All of the alternatives will call for filling the site with an engineering controlled material. In addition, the existing slag-contaminated soil on site, after initial site grading as part of remediation, will provide excellent subgrade support for both structure foundations and slab and pavement sections. The low permeability cover material (Alternative 4) and the stabilized soil (Alternative 7) will be somewhat more difficult to incorporate into future development of the site.

4.8 Preferred Alternative for Slag-Contaminated Soil

The preferred alternative for the slag-contaminated soil is Alternative 3, Cover the Site with Two Feet of Compacted Sand and Gravel Fill.

All of the remaining alternatives effectively meet the cleanup objectives, are protective, and are in compliance with ARARs.

Alternative 6 (excavate material and landfill) and Alternative 7 (stabilize the material on site) are eliminated because any increase in protectiveness over the other alternatives is not substantiated by the order of magnitude increase in cost, i.e., these alternatives are not cost-effective.

Alternative 4 (cover with a low permeability soil) is not preferred because protection of groundwater is not a cleanup objective in this case and because use of this type of material would delay construction until dry weather periods. In addition, special measure would need to be implemented every time this cover needed to be excavated as part of long-term site development (i.e., foundations, utilities, etc.); it would need to be replaced in its former condition which might be difficult during wet weather periods (because of the moisture sensitivity of the cover material).

Alternative 5 (paving) offers no appreciable protection from direct exposure to the slag-contaminated soil than Alternative 3 (sand and gravel) and therefore there would appear to be no justification for the significant increase in cost of Alternative 5 over Alternative 3.

As a result we propose Alternative 3 as the Preferred Alternative for the Slag-Contaminated Soil.

Table 4-1 - OFA/Pennwalt Area - Slag-Contaminated Soil

Alternative Number	Alternative Description	Protectiveness	Comply with ARARs	Reduction of Toxicity, Mobility, or Volume	Long-Term Effectiveness	Implementability	Short-Term Effectiveness	Compatible with Site Development	Require Monitoring	Require Institutional Controls	Estimated Cost
1	Baseline Condition	Cleanup objectives not met. Future exposures likely. Not protective locally.	No	No	Poor	Feasible. No admin restrictions. No adverse schedule impacts.	Low risk	Yes	Yes	H&S Plan for future site work	\$2,800
2	Site Grading	Cleanup objectives not met. Future exposures likely. Not protective locally.	No	No	Poor	Feasible. No admin restrictions. No adverse schedule impacts.	Moderate risk	Yes	Yes	H&S Plan for future site work	\$151,600
3	Site Grading and Cap with Sand and Gravel Fill	All cleanup objectives met. Future exposures not likely. Locally protective. More protective of society.	Yes	Mobility of copper	Good	Feasible. No admin restrictions. No adverse schedule impacts.	Moderate risk	Yes	Yes	H&S Plan for future site work	\$896,000
4	Site Grading and Cap with Low Permeability Fill	All cleanup objectives met. Future exposures not likely. Locally protective. More protective of society.	Yes	Mobility of copper	Good	Feasible. No admin restrictions. Adverse schedule impacts.	Moderate risk	Yes	Yes	H&S Plan for future site work	\$1,054,900
5	Site Grading and Cap with Sand and Gravel with Asphalt Pavement	All cleanup objectives met. Future exposures not likely. Locally protective. More protective of society.	Yes	Mobility of copper	Good	Feasible. No admin restrictions. No adverse schedule impacts.	Moderate risk	Yes	Yes	H&S Plan for future site work	\$1,453,300
6	Excavate Soil and Landfill	All cleanup objectives met. Future exposures not likely. Locally protective. Less protective of society (transport).	Yes	Mobility	Excellent	Feasible. No admin restrictions. Possible adverse schedule impacts.	Moderate risk	Yes	No	No	\$17,972,700
7	Excavate, Stabilize, and Replace Soil	All cleanup objectives met. Future exposures not likely. Locally protective. More protective of society.	Yes	Large reduction in mobility	Good	Feasible. No admin restrictions. Adverse schedule impacts.	Moderate risk	Yes	Yes	H&S Plan for future site work	\$9,745,500

235020\SLAGCONT.TBL

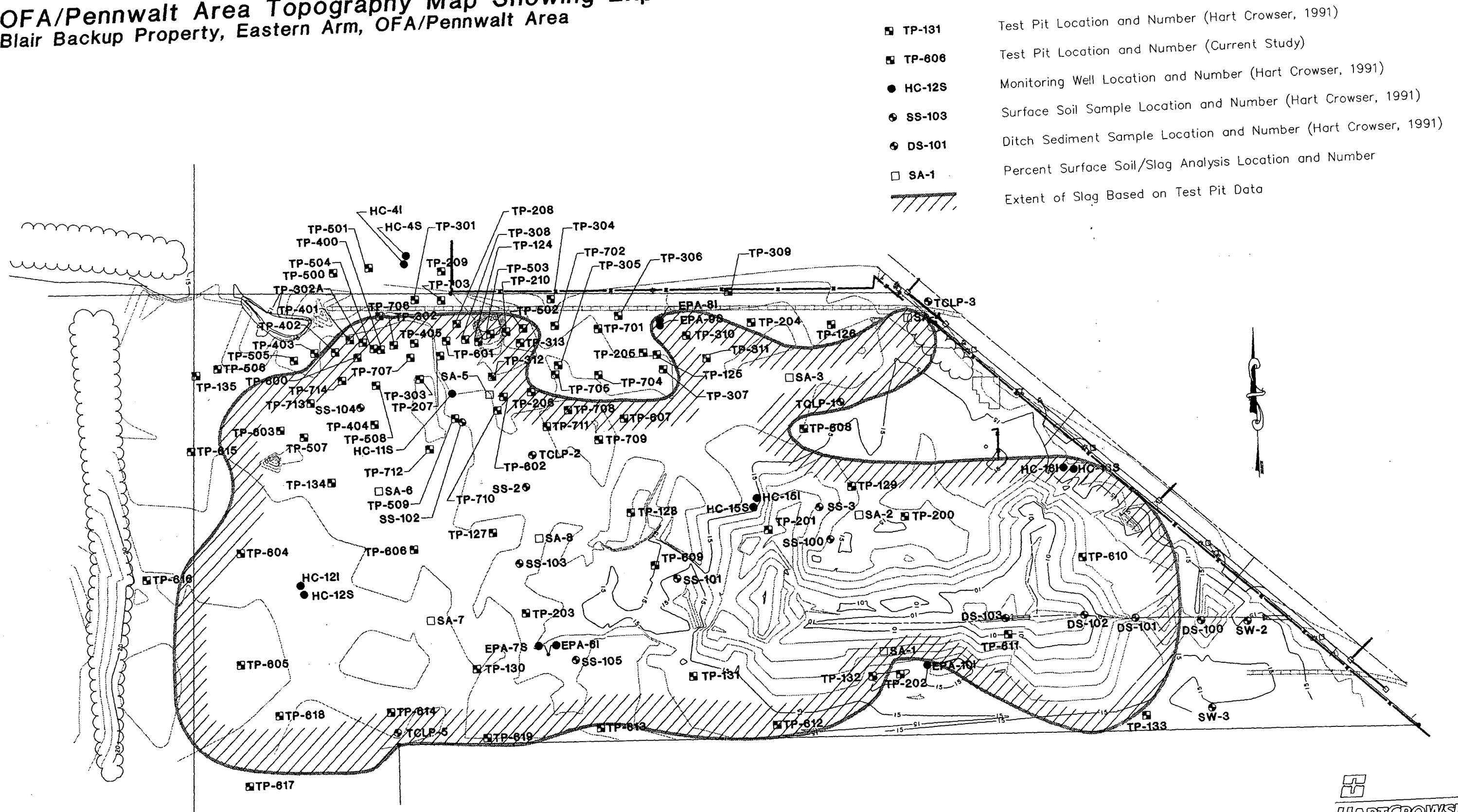
151,500
on p. 4-23

OFA/Pennwalt Area Topography Map Showing Explorations and Extent of Slag
Blair Backup Property, Eastern Arm, OFA/Pennwalt Area

TP-131








Test


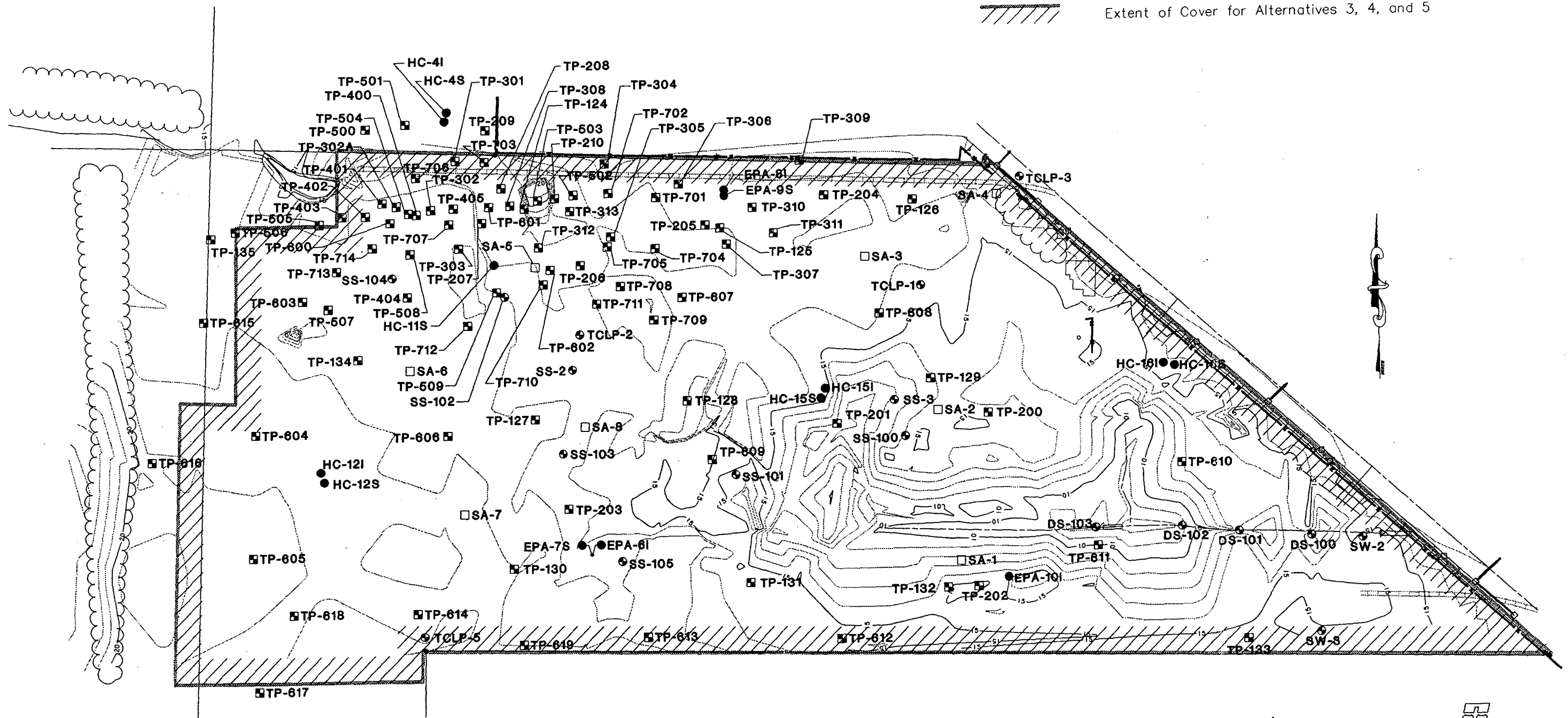
Test



0 120 240
Scale in Feet

Extent of Cover for Alternatives 3, 4, and 5
Blair Backup Property, Eastern Arm, OFA/Pennwalt Area

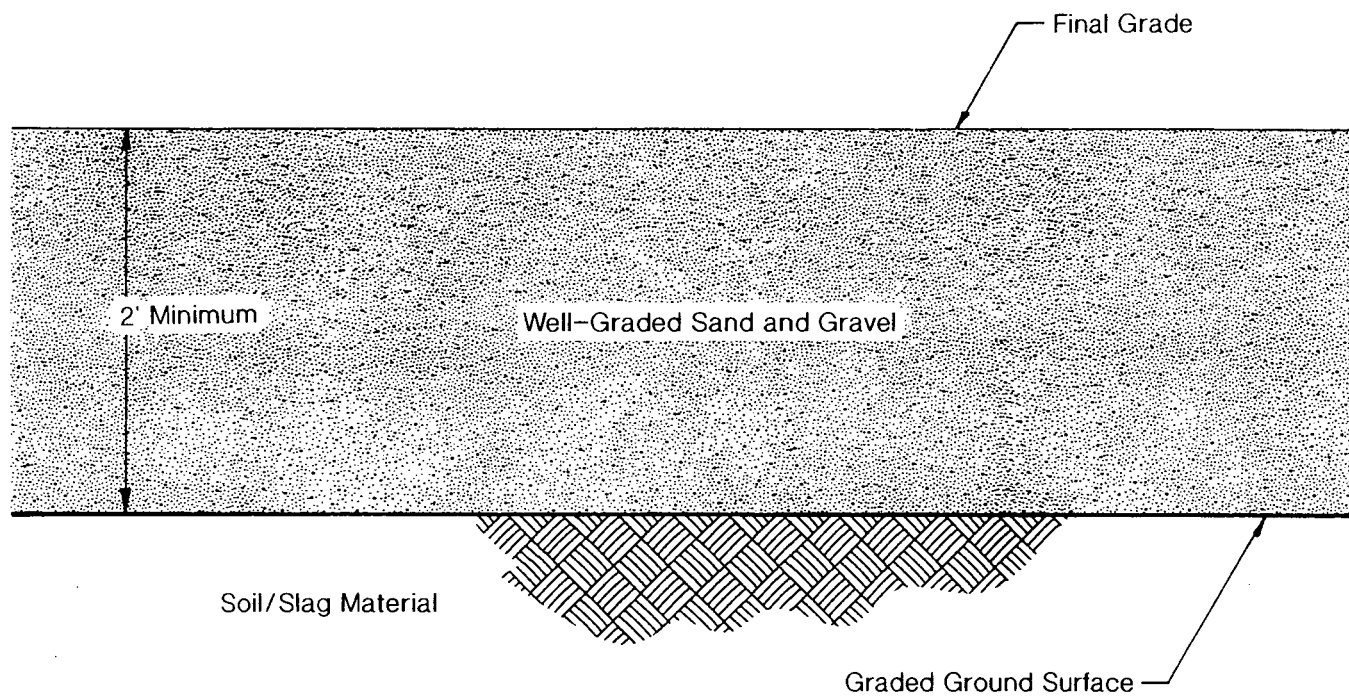
- | | |
|---|--|
|  TP-131 | Test Pit Location and Number (Hart Crowser, 1991) |
|  TP-606 | Test Pit Location and Number (Current Study) |
|  HC-12S | Monitoring Well Location and Number (Hart Crowser, 1991) |
|  SS-103 | Surface Soil Sample Location and Number (Hart Crowser, 1991) |
|  DS-101 | Ditch Sediment Sample Location and Number (Hart Crowser, 1991) |
|  SA-1 | Percent Surface Soil/Slag Analysis Location and Number |
|  | Extent of Cover for Alternatives 3, 4, and 5 |



A horizontal scale bar with markings at 0, 120, and 240. Below the bar is the text "Scale in Feet".

Typical Cover Section

Alternative 3



Not to Scale



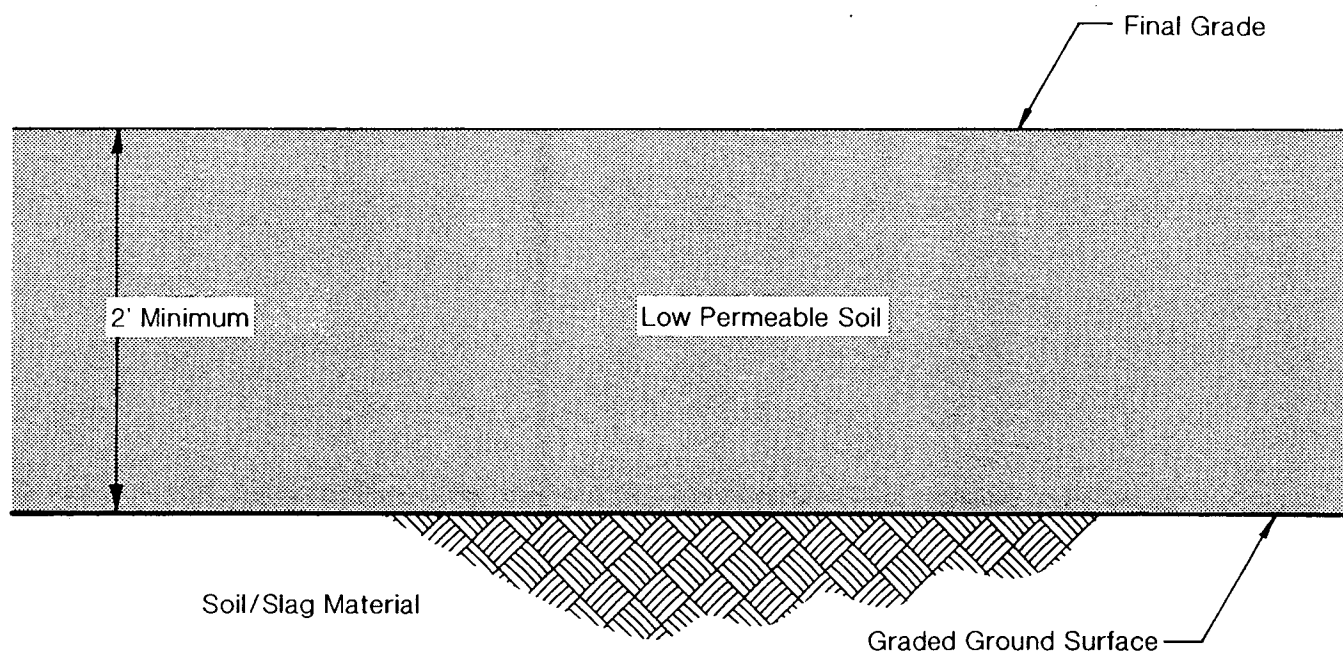
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Figure 4-3

Typical Cover Section

Alternative 4



Not to Scale



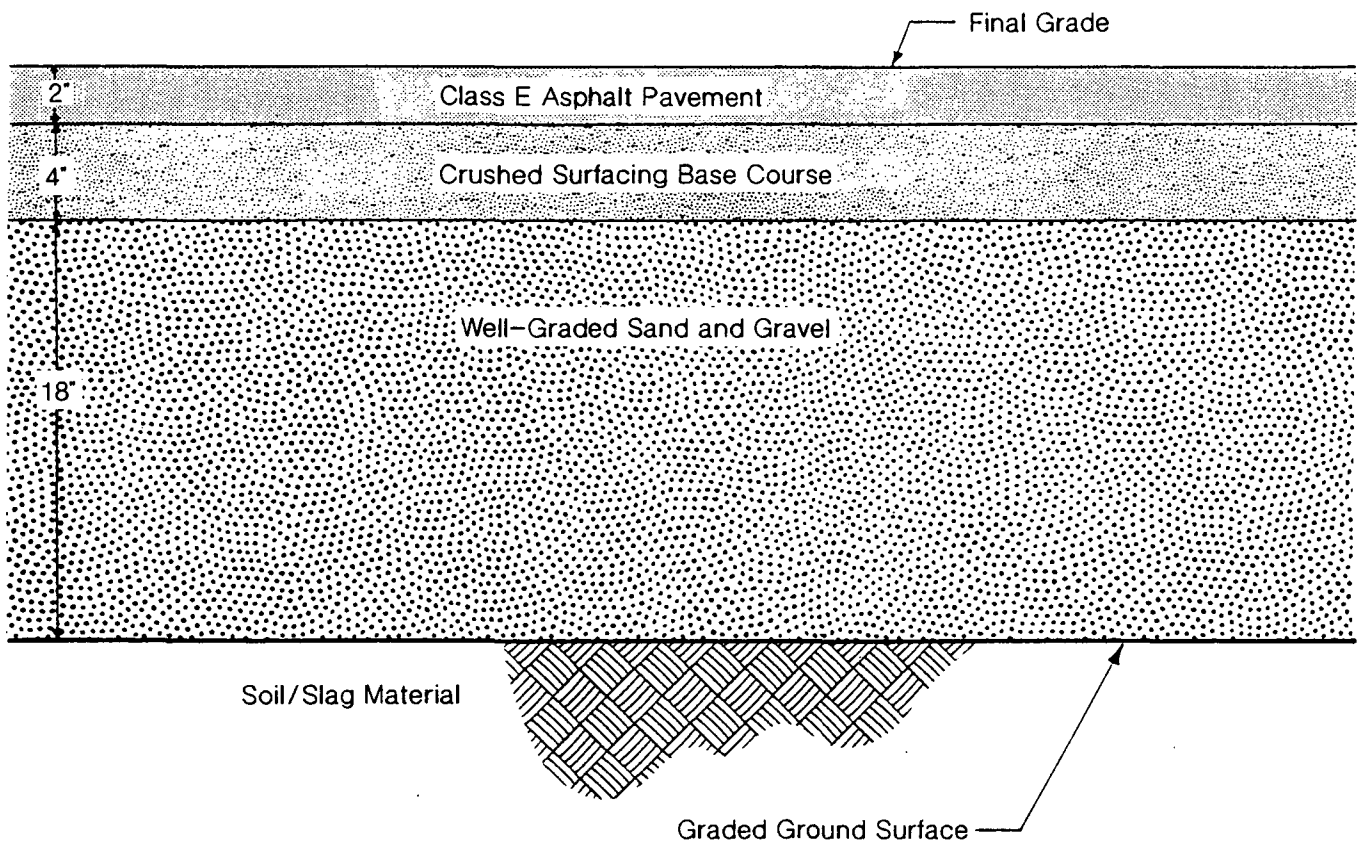
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Figure 4-4

Typical Cover Section

Alternative 5



Not to Scale

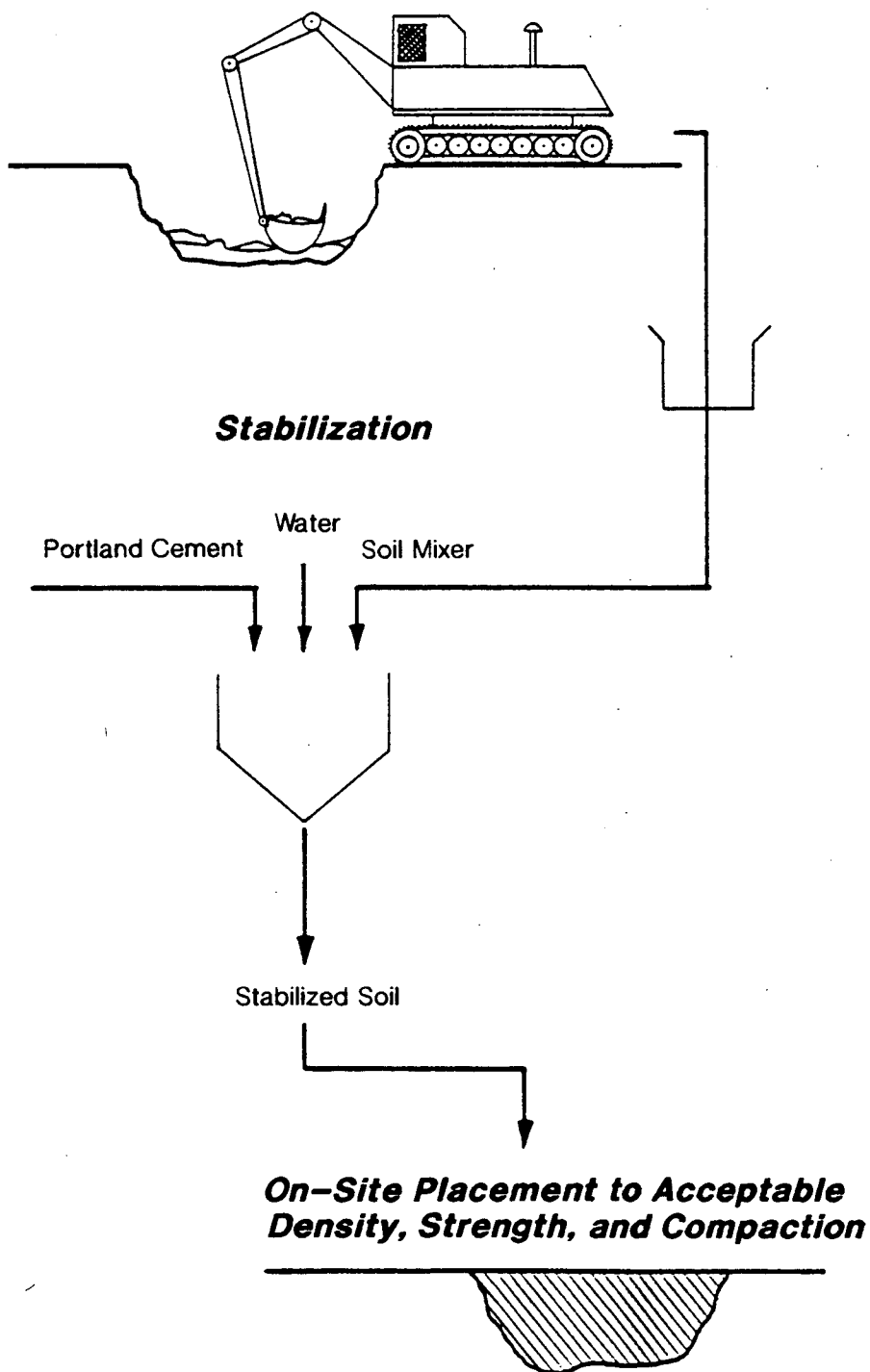


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Figure 4-5

Process Diagram for Stabilization Alternative 7 for Slag-Contaminated Soil



Not to Scale



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Figure 4-6

5.0 EVALUATION OF ALTERNATIVES FOR PAH-CONTAMINATED SOILS

5.1 *Extent and Volume of PAH-Contaminated Material*

About two acres of the former OFA Smelter site (within the OFA/Pennwalt Area) is impacted with PAH contamination as shown on Figures 5-1 through 5-3. The location of the impacted area with respect to the OFA/Pennwalt Area is shown on Figure 2-2. Extensive explorations show about 13,000 cy of material to maximum explored depths of about six feet. The material is primarily soil and debris, but discrete lenses and zones of charcoal briquettes are located within the area. The volume of material which comprises the total 13,000 cy is defined by a line circumscribing the area where total cPAH concentrations from our test results may exceed the MTCA cleanup level of 20 mg/kg.

A more detailed description of the explorations, sampling, and testing of materials in this area is presented in Appendix E.

For purposes of evaluating cleanup alternatives we have broken the PAH-contaminated material into two categories as follows:

Charcoal Briquettes. This material as outlined on Figure 5-1 consists of about 4,100 cy of charcoal briquettes interlayered with sand and gravel fill materials. This volume was computed by noting the extent of explorations where distinct lenses or zones of briquettes were visually observed. The maximum depth of the briquettes as encountered in the test pit explorations was six feet. The total volume was therefore computed as the area multiplied by a depth of six feet. The total volume of actual charcoal briquettes is lower than the 4,100 cy because of the presence of the soil interlayered with the briquettes. Analytical testing reveals that the concentrations of cPAHs in the area of charcoal briquettes ranges from close to zero to 8,900 mg/kg.

PAH-Contaminated Soil. Approximately 8,900 cy consist of soil and some debris contaminated with varying concentrations of cPAHs. Of this volume we estimate that perhaps 1,900 cy are contaminated, i.e., concentrations greater than 100 to 200 mg/kg. For purposes of this analysis of alternatives it has been assumed that the entire volume of material with concentrations exceeding 20 mg/kg total cPAHs is subject to cleanup.

5.2 *Cleanup Objectives—Prevent Human Contact with PAH-Contaminated Soil*

As stated in Section 3.0, the cleanup objectives for the OFA/Pennwalt Area of the Blair Backup property is based on a review of the chemicals and media identified

for cleanup as well as ARARs and other methods used to determine appropriate cleanup levels. The cleanup objective is a statement of the goal of the proposed remedial action at the OFA/Pennwalt Area.

The cleanup objectives for the PAH-contaminated material in the OFA/Pennwalt Area are:

- ▶ Prevent human contact (ingestion, direct contact, and inhalation) of soils with elevated cPAH concentrations.

5.3 Identification and Screening of Technology Types

As explained above, PAH-contaminated material has two distinct components;

- ▶ PAH-Contaminated Soil (8,900 cy), and
- ▶ Charcoal Briquettes (4,100 cy)

Cleanup technologies for each of these materials are considered separately because of differences in the type of material, level of contamination, and viability of the treatment technologies. Initial screening of technologies for both the charcoal and PAH soil showed that cleanup technologies appropriate for the OFA Area slag/soil are also appropriate and generally protective for the PAH material. This is because the cleanup objectives are the same for both the OFA slag/soil and the PAH material (i.e., to preclude direct contact and ingestion). In addition, as part of our initial screening we considered incineration and burning as well as bioremediation.

The available remedial technologies for the PAH-contaminated material were screened using Effectiveness, Implementability, and Cost criteria, as was used for the slag-contaminated soil. The technologies eliminated by this process were the same as those eliminated for consideration for the slag material except that incineration and burning were retained as a viable alternatives. Bioremediation was not considered applicable to the charcoal briquettes because elaborate pretreatment (crushing and screening) would have resulted in relatively high short-term risks and because the very high concentration of PAHs in the briquettes likely preclude attainable cleanup criteria. Bioremediation was not considered for the PAH-contaminated soil because the contaminants are considered only marginally degradable and because the process is highly susceptible to disruption due to variable weather conditions. We did not retain burning or incineration of the PAH-contaminated soil because of high cost and their low fuel value; however, we did retain these options for the briquettes.

5.4 Development of Remedial Alternatives

5.4.1 Identification of Alternatives

The process of formulating alternatives from the applicable technologies for the PAH-contaminated material was essentially the same as that used for the slag-contaminated soil. As with the slag material some of the possible alternatives were eliminated by inspection. The resulting overall alternatives retained as applicable are as follows.

1. No Action
2. Site Grading
3. Cover with Sand and Gravel
4. Cover with Low Permeability Soil
5. Cover with Sand and Gravel and Asphalt Pavement
6. Excavation and Landfilling
7. Stabilization
8. Excavation and Burning
9. Excavation and Incineration
10. Low Permeability Cap System

As can be seen these alternatives are generally similar to the alternatives considered for the OFA slag/soil. This is because the cleanup objectives for both areas are essentially the same. Therefore the alternatives considered for the PAH-contaminated material should be compatible with the preferred alternative for the OFA slag/soil.

The "no action" alternative and "site grading and erosion control" were dropped from consideration because of the same criteria discussed for these alternatives in Section 4. The analysis of alternatives for the PAH material will therefore focus upon the assembling of technologies that apply to the charcoal briquettes and the technologies that apply to the PAH-contaminated soils. This range of potential alternatives will then be considered in respect to inclusion within the Preferred Cleanup Alternative for the OFA slag/soil.

5.4.2 Alternatives Applicable to Charcoal Briquettes

- **Landfill.** This technology would include overexcavation of the charcoal briquettes and then transport and disposal at a licensed, secure landfill. For purposes of this analysis, we assume the charcoal briquettes and associated briquette-contaminated soil would be disposed of in a RCRA permitted solid

waste landfill. This assumption is predicated upon the granting of the Port of Tacoma's Petition for Exemption of Charcoal Briquettes and Charcoal-Contaminated Soil from the Washington State Dangerous Waste Regulations, Chapter 173-303 WAC, dated November 9, 1992. In this petition, two landfills are identified for material disposal; the Roosevelt Regional Landfill in Klickitat County, Washington (operated by Rabanco, Inc.) and the Columbia Ridge Landfill near Arlington, Oregon (operated by Oregon Waste Systems, Inc.).

In summary, the data have been compared to Federal Hazardous Waste Characteristics of Dangerous Waste Lists, Ignitability, Corrosivity, Reactivity, and Toxicity Characteristics. The charcoal/soil is NOT Dangerous Waste under these criteria. The data have also been compared to Washington State Dangerous Waste Characteristics of Acute Toxicity, Persistence, and Carcinogenicity. Based on the results of toxicity characteristic leaching procedure (TCLP) testing and other data presented in the Petition the charcoal and soil mixture is a dangerous waste based on Acute Toxicity.

This Petition for Exemption should be referred to for a detailed discussion and data presentation with regard to waste characterization of the excavated charcoal/soil mixture. The estimated cost for this alternative is \$555,605.

- ▶ **Burning.** Given the high fuel value of the charcoal and the nature of the contaminants it is likely that the charcoal could be burned at a licensed hydrocarbon combustion facility (e.g., REMTECH). The remediation would consist of excavation of the charcoal briquettes, transport by rail to an appropriate facility, and then burning in an approved combustion unit. Costs for this alternative would be approximately \$1,051,027.
- ▶ **Incineration.** Incineration would include overexcavation of the charcoal briquettes, transport (possibly by rail) to a licensed hazardous waste incinerator, and incineration. Costs for this alternative are approximately \$6,797,577.
- ▶ **Cover with Sand and Gravel and Asphalt Pavement Cap.** This would include grading the site as part of incorporation into the preferred alternative for the slag-contaminated soil discussed in Section 4. In addition the area would be covered with a pavement section to further "harden" the site against unintentional excavation.

5.4.3 Alternatives Applicable to PAH-Contaminated Soil

- ▶ **Cover and Leave in Place.** This alternative would consist of grading the site, filling to appropriate elevation to promote drainage, and then capping the area with one of the several methods discussed in Section 4. This alternative would be accomplished as part of application of this technology to the entire site as described in Section 4. The area containing PAHs was included when cost estimates were calculated for the OFA soil/slag material therefore no additional cost would be incurred. The actual cost associated with this portion of the work would, however, be about \$60,000 per acre.
- ▶ **Stabilization.** This alternative would include overexcavation of the PAH-contaminated soil, addition of a stabilizing agent to the excavated soil, and then backfilling the stabilized soil into the original excavation. The cost to stabilize the estimated 8,900 cy of impacted soil would be approximately \$1,137,000.
- ▶ **Landfill.** This alternative would include overexcavation of the PAH-contaminated soil and transport and disposal at a solid waste (i.e., not a "Dangerous Waste") landfill. Estimated cost for this alternative is \$1,116,000.

5.5 Description of Alternatives

The three alternatives applicable to the PAH-contaminated soil could be combined with any of the alternatives for the charcoal briquettes.

Ten reasonable combinations of possible alternatives are presented below.

5.5.1 Landfill Briquettes/Cover PAH-Contaminated Soil with Sand and Gravel

This alternative would consist of excavation of the charcoal briquettes and transportation of the briquettes to an approved solid waste landfill (either the Roosevelt Regional Landfill or the Columbia Ridge Landfill) subject to grading of the Port's Petition for Exemption. Stabilization of the excavated material would probably be required before it was placed in the landfill. The excavation would be backfilled with clean material. The PAH-contaminated soil would remain in place and the area would be graded, filled to elevation, and capped as part of the slag/soil remediation as previously described in Section 4. As the site is overexcavated and backfilled the final elevation of the backfill material will be graded to drain the site. Erosion and dust control measures will be established.

This alternative would leave PAH-contaminated soil in place on the site. Institutional controls would be implemented to reduce exposure to the material left on site. These institutional controls would include:

- ▶ Restricting use of groundwater from the shallow and intermediate aquifers at the site for use as drinking water;
- ▶ Require that health and safety plans and provisions be observed during future subsurface work at the site that may expose workers to the PAH-contaminated material and require that personnel involved with subsurface work be health and safety trained; and
- ▶ Provide appropriate notification to current and future owners and tenants as well as persons engaged in pertinent on site activities.

5.5.2 Landfill Briquettes/Stabilize PAH-Contaminated Soil

This alternative would consist of excavating and landfilling the briquettes, as described in Section 5.5.1 and excavation, stabilization, and backfilling the PAH-contaminated soil.

Treatment of the PAH-contaminated soil will require excavating the soil. The trackhoe will begin at one end of the site excavating a wide trench. The trackhoe will load trucks as it excavates. The trucks will haul the PAH-contaminated soil to an area of the site set up with the solidification/stabilization point. Figure 4-6 illustrates the procedure.

The solidification/stabilization process will consist of the addition of Portland cement and other materials (based on treatability testing) to the PAH-contaminated soil. Cement would be added in the range of 3 to 12 percent in order to create a compacted soil-cement. The soil would probably require screening and crushing of large particles; the crushed particles would be added back to the soil mix. The processed mix of soil and cement would be designed to provide relatively low permeability, good strength, compactibility, and adequate pH control. Additives may be added, if necessary, to reduce shrinkage upon curing.

As the trench is advanced down the site, the trench is backfilled with the stabilized PAH soil material via cement or dump trucks. Compaction of each lift would be performed. As the site is overexcavated and backfilled the final elevation of the backfill material will be graded to drain the site. Erosion and dust control measures will be established.

Institutional controls would consist of restrictions on use of groundwater, requirements for health and safety provisions for subsurface work, and notification requirements as discussed earlier.

5.5.3 Landfill Briquettes/Landfill PAH-Contaminated Soil

This alternative would consist of excavation and landfilling of the charcoal briquettes as previously described in Section 5.5.1, and excavation and landfilling of the PAH-contaminated soil at a solid waste landfill.

This alternative will first consist of excavating the PAH-contaminated material. The PAH-contaminated material will be excavated with a trackhoe using a "cut and cover" technique. The trackhoe will begin at one end of the site excavating a wide trench. The trackhoe will load trucks as it excavates. The trucks will haul the PAH-contaminated soil to an approved land disposal area.

As the trench is advanced down the site, the trench will be backfilled with select fill, typically a well-graded sand and gravel. The fill will be brought to the site by truck, spread by bulldozer or grader, and compacted with vibratory rollers. As the site is excavated and backfilled the final elevation of the backfill material will be graded to drain the site. Erosion and dust control measures will be established.

5.5.4 Burn Briquettes/Cover PAH-Contaminated Soil with Sand and Gravel

This alternative would combine burning the charcoal briquettes at a licensed hydrocarbon combustion facility and covering the PAH-contaminated soil as described in Section 5.5.1.

The charcoal briquettes would be overexcavated by track-hoe, loaded on rail cars, and transported to a licensed facility where they would be burned. The excavation would be backfilled with clean fill and the site would then be graded, filled, and covered with a cap as previously described.

Institutional controls would consist of restrictions on use of groundwater, requirements for health and safety provisions for subsurface work, and notification requirements as discussed earlier.

5.5.5 Burn Briquettes/Stabilize PAH-Contaminated Soil

This alternative would combine burning of the charcoal briquettes as described above with excavation, stabilization, and backfilling the PAH-contaminated soil as described in Section 5.5.2.

Institutional controls would consist of restrictions on use of groundwater, requirements for health and safety provisions for subsurface work, and notification requirements as discussed earlier.

5.5.6 Burn Briquettes/Landfill PAH-Contaminated Soil

This alternative would combine burning the charcoal briquettes as described in Section 5.5.4 with landfilling the PAH-contaminated soil as described in Section 5.5.3.

5.5.7 Incinerate Briquettes/Cover PAH-Contaminated Soil with Sand and Gravel

This alternative would include leaving the PAH-contaminated soil in place and covering the site as previously described with incineration of the charcoal briquettes at an approved hazardous waste incinerator.

The charcoal briquettes would be excavated as described in previous sections, then hauled (by rail or truck) to an EPA-approved hazardous waste incinerator.

Institutional controls would consist of restrictions on use of groundwater, requirements for health and safety provisions for subsurface work, and notification requirements as discussed earlier.

5.5.8 Incinerate Briquettes/Stabilize PAH-Contaminated Soil

This alternative would combine incineration of the charcoal briquettes as described above with excavation, stabilization, and backfilling the PAH-contaminated soil as described in Section 5.5.3.

Institutional controls would consist of restrictions on use of groundwater, requirements for health and safety provisions for subsurface work, and notification requirements as discussed earlier.

5.5.9 Incinerate Briquettes/Landfill PAH-Contaminated Soil

This alternative would combine incineration the charcoal briquettes as described in Section 5.5.7 with landfilling the PAH-contaminated soil as described in Section 5.5.3.

5.5.10 Cap Briquettes with Pavement/Cap PAH-Contaminated Soil with Pavement

This alternative would consist of leaving all material on site and covering the charcoal briquettes as well as the PAH-contaminated soil. A minimum of 14 inches of sand and gravel would be placed over the *in situ* materials. In order to "harden" the site the briquettes area would also be covered with an asphalt pavement section also designed to help minimize surface water infiltration which in turn helps to extend the life of this pavement. Considering that one would want to extend the covered area outside of the immediate area of the briquettes to provide a "factor of safety" the area which would be paved would include the entire area within the "20 mg/kg" concentration isopleth line shown on Figure 5-1.

The pavement section would consist of 6 inches of crushed rock base course overlain by two lifts of asphalt concrete between which would be placed an asphalt impregnated geotextile membrane. The overall thickness of the cap would be two feet. In order to protect the asphalt cap from wear and tear a protective layer of clean 3/4-inch minus sand and gravel or crushed rock would be placed over the asphalt cap. A schematic cross section through the cap is shown on Figure 5-4.

Institutional controls would consist of restrictions on use of groundwater, requirements for health and safety provisions for subsurface work, and notification requirements as discussed earlier.

5.6 Evaluation of Alternatives

The evaluation criteria for alternatives as presented in Section 4.5 apply to the evaluation of these alternatives.

5.6.1 Alternative 1 - Landfill Briquettes and Cover PAH-Contaminated Soil

The key considerations associated with this alternative are:

- ▶ Precludes contact with cPAHs within the charcoal and PAH-contaminated soil and therefore is protective of human health and the environment.

- ▶ The material with the highest concentrations of cPAHs is removed from the site.
- ▶ The site is prepared for development.
- ▶ High cost.
- ▶ Because some PAH contamination would remain on site the need for institutional controls would remain.

Overall Protection of Human Health and the Environment. This alternative precludes direct contact with the briquettes as well as the PAH-contaminated soil. As such it meets the cleanup objectives for the site and is therefore protective of human health and the environment.

Compliance with ARARs. Chemical-specific ARARs associated with this remedial alternative include MTCA Method A industrial cleanup levels for PAHs. The cleanup requirement to protect against direct contact with PAHs is met with this alternative because the material is either removed from the site or covered with two feet of sand and gravel fill material.

Action-specific provisions of the Washington State Dangerous Waste regulations concerning transportation, storage, and disposal of the waste may apply. These ARARs will determine the appropriate disposal method and location of the excavated material. Since the PAH-contaminated soil is not removed from the area and groundwater is not a cleanup objective, the Washington State Dangerous Waste Regulations would only be relevant and appropriate to substantive provisions of the cover design.

Implementability. This alternative will use standard earth moving equipment for site excavation and grading, and sand and gravel importing, placing, and compacting. Because standard equipment and methods will be used, minimal difficulties or unknowns are associated with construction. The technology is well established and services and materials should be readily available.

Short-Term Effectiveness. The alternative will take a relatively short time to implement. The risks to the workers during construction are the same as the risks that the alternative is intended to mitigate. Therefore the overall risk to workers during construction is low provided the institutional controls discussed for this alternative are implemented.

Long-Term Effectiveness. The proposed technologies are simple and reliable. Given proper and simple maintenance of the sand and gravel cover the alternative will perform as well in the future as it will immediately following construction. Maintenance technologies are also simple and effective.

Reduction of Toxicity, Mobility, or Volume through Treatment. This alternative does not reduce toxicity, mobility, or volume.

Cost. Cost is approximately \$555,605. Refer to Appendix G for a more detailed cost analysis.

Effects on Site Development. There will be minimal impact to site development from this alternative. Placement of sand and gravel fill will provide an excellent subgrade for subsequent paving operations. Repair and maintenance of the cover will be simple and cost-effective.

5.6.2 Alternative 2 - Landfill Briquettes and Stabilize PAH-Contaminated Soil

The key considerations associated with this alternative are:

- ▶ Precludes contact with cPAHs within the charcoal and PAH-contaminated soil and therefore is protective of human health and the environment.
- ▶ The material with the highest concentrations of cPAHs is removed from the site.
- ▶ The site is prepared for development.
- ▶ High cost.
- ▶ Because some PAH contamination would remain on site the need for institutional controls would remain.
- ▶ There is uncertainty about the effectiveness of applying stabilization techniques because of the organic nature of the material.

Overall Protection of Human Health and the Environment. This alternative precludes direct contact with the briquettes as well as the PAH-contaminated soil. As such it meets the cleanup objectives for the site and is therefore protective of human health and the environment.

Compliance with ARARs. Chemical-specific ARARs associated with this remedial alternative include MTCA Method A industrial cleanup levels for PAHs. The cleanup requirement to protect against direct contact with PAHs is met with this alternative because the material is either removed from the site or chemically stabilized and covered with two feet of sand and gravel.

Action-specific provisions of the Washington State Dangerous Waste Regulations concerning transportation, storage, and disposal of the waste may apply. These ARARs will determine the appropriate disposal method and location of the excavated material. Since the PAH-contaminated soil is not removed from the area and groundwater protection is not a cleanup objective, the Washington State Dangerous Waste Regulations would only be relevant and appropriate to substantive provisions of the cover design.

Implementability. This alternative will use standard earth moving equipment for site excavation and grading, and sand and gravel importing, placing and compacting. Because standard equipment and methods will be used, minimal difficulties or unknowns are associated with construction. The technology is well established and services and materials should be readily available. Difficulties and/or uncertainties may be encountered since a large area of PAH-contaminated soil will be excavated. High groundwater and potential unexpected conditions can also make excavation difficult.

Because of the high organics content of PAH soil in some areas it may be very difficult to stabilize/solidify the material. Test sections prior to work will be required to show that the process can be performed as planned and establishing a workable procedure may take time.

Short-Term Effectiveness. The alternative will take a relatively short time to implement with the stabilization portion taking somewhat longer. The risks to the workers during construction are the same as the risks that the alternative is intended to mitigate. Therefore the overall risk to workers during construction is low provided the institutional controls discussed for this alternative are implemented.

Long-Term Effectiveness. The proposed technologies associated with excavation and filling which will be used are simple and reliable. Given proper and simple maintenance of the sand and gravel cover the alternative will perform as well in the future as it will immediately following construction. Maintenance technologies are also simple and effective. The reliability of cement stabilization over the long-term is not as well determined as technologies using natural earthen materials. The effectiveness of the technology may deteriorate over time.

Reduction of Toxicity, Mobility, or Volume through Treatment. The mobility of the cPAHs left on site and stabilized will be reduced. The toxicity, mobility, and volume of the briquettes will remain unchanged.

Cost. Cost is approximately \$1,692,294. Refer to Appendix G for a more detailed cost analysis.

Effects on Site Development. There are potential adverse impacts on site development due to the presence of stabilized material which will need to be excavated for placement of utilities and foundations. Heavier equipment will be required for this type of work. The stabilized material should, however, provide excellent subgrade support.

5.6.3 Alternative 3 - Landfill Briquettes and Landfill PAH-Contaminated Soil

The key considerations associated with this alternative are:

- ▶ Precludes contact with cPAHs within the charcoal and PAH soil and therefore is protective of human health and the environment.
- ▶ All material is removed from the site.
- ▶ The site is prepared for development.
- ▶ There would be no need for institutional controls for this area.
- ▶ Very high cost.

Overall Protection of Human Health and the Environment. This alternative precludes direct contact with the briquettes as well as the PAH-contaminated soil. As such it meets the cleanup objectives for the site and is therefore protective of human health and the environment.

Compliance with ARARs. Chemical-specific ARARs associated with this remedial alternative include MTCA Method A industrial cleanup levels for PAHs. The cleanup requirement to protect against direct contact with PAHs is met with this alternative because the material is removed from the site.

Action-specific provisions of the Washington State Dangerous Waste Regulations concerning transportation, storage, and disposal of the waste may apply. These

ARARs will determine the appropriate disposal method and location of the excavated material.

Implementability. This alternative will use standard earth moving equipment for site excavation and grading, and sand and gravel importing, placing, and compacting. Because standard equipment and methods will be used, minimal difficulties or unknowns are associated with construction. The technology is well established and services and materials should be readily available. Difficulties and/or uncertainties may be encountered since a large area of PAH-contaminated soil will be excavated. High groundwater and potential unexpected conditions can also make excavation difficult.

Short-Term Effectiveness. The alternative will take a relatively short time to implement. The risks to the workers during construction are the same as the risks that the alternative is intended to mitigate. Therefore the overall risk to workers during construction is low provided the institutional controls discussed for this alternative are implemented.

Long-Term Effectiveness. The proposed technologies which will be used are simple and reliable. No maintenance will be required.

Reduction of Toxicity, Mobility, or Volume through Treatment. This alternative does not reduce toxicity, mobility, or volume.

Cost. Cost is approximately \$1,671,629. Refer to Appendix G for a more detailed cost analysis.

Effects on Site Development. There will be no adverse impacts to future site development. The sand and gravel backfill will provide excellent support for foundations, pavements, and slabs.

5.6.4 Alternative 4 - Burn Briquettes and Cover PAH-Contaminated Soil

The key considerations associated with this alternative are:

- ▶ Precludes contact with cPAHs within the charcoal and PAH soil and therefore is protective of human health and the environment.
- ▶ The material with the highest concentrations of cPAHs is removed from the site.

- ▶ The material with the highest concentration of cPAHs is permanently destroyed.
- ▶ The site is prepared for development.
- ▶ Comparatively low cost.
- ▶ Because some PAH contamination would remain on site the need for institutional controls would remain.

Overall Protection of Human Health and the Environment. This alternative precludes direct contact with the briquettes as well as the PAH-contaminated soil. As such it meets the cleanup objectives for the site and is therefore protective of human health and the environment.

Compliance with ARARs. Chemical-specific ARARs associated with this remedial alternative include MTCA Method A industrial cleanup levels for PAHs. The cleanup requirement to protect against direct contact with PAHs is met with this alternative because the material is either removed from the site or covered with two feet of sand and gravel fill material.

Action-specific provisions of the Washington State Dangerous Waste Regulations concerning transportation, storage, and disposal of the waste may apply. Because the briquettes were originally used as a fuel they may likely be considered a product if they are considered a fuel in a burning process. Under these circumstances the Washington State Dangerous Waste Regulations would not apply to burning. Since the PAH-contaminated soil is not removed from the area and groundwater protection is not a cleanup objective, the Washington State Dangerous Waste Regulations would be only relevant and appropriate with regard to substantive provisions of the cover design.

Implementability. This alternative will use standard earth moving equipment for site excavation and grading, burning, and sand and gravel importing, placing, and compacting. Because standard equipment and methods will be used, minimal difficulties or unknowns are associated with construction. The technology is well established and services and materials should be readily available.

Short-Term Effectiveness. The alternative will take a relatively short time to implement. The risks to the workers during construction are the same as the risks that the alternative is intended to mitigate. Therefore the overall risk to workers

during construction is low provided the institutional controls discussed for the alternative are implemented.

Long-Term Effectiveness. The proposed technologies are simple and reliable. Given proper and simple maintenance of the sand and gravel cover the alternative will perform as well in the future as it will immediately following construction. Maintenance technologies are also simple and effective. Because the briquettes are destroyed, the long-term effectiveness associated with the majority of the cPAHs is excellent.

Reduction of Toxicity, Mobility, or Volume through Treatment. This alternative reduces the mobility, toxicity, and volume of the briquettes but does not reduce toxicity, mobility, or volume of the PAH-contaminated soil.

Cost. The cost is approximately \$1,051,027. Refer to Appendix G for a more detailed cost analysis.

Effects on Site Development. There will be minimal impact to site development from this alternative. Placement of sand and gravel fill will provide an excellent subgrade for subsequent paving operations. Repair and maintenance of the cover will be simple and cost-effective.

5.6.5 Alternative 5 - Burn Briquettes and Stabilize PAH-Contaminated Soil

The key considerations associated with this alternative are:

- ▶ Precludes contact with cPAHs within the charcoal and PAH-contaminated soil and therefore is protective of human health and the environment.
- ▶ The material with the highest concentrations of cPAHs is removed from the site.
- ▶ The material with the highest concentrations of cPAHs is permanently destroyed.
- ▶ The site is prepared for development.
- ▶ High cost.
- ▶ Because some PAH contamination would remain on site the need for institutional controls would remain.

- There is uncertainty about the effectiveness of applying stabilization techniques to this type of organic material.

Overall Protection of Human Health and the Environment. This alternative precludes direct contact with the briquettes as well as the PAH-contaminated soil. As such it meets the cleanup objectives for the site and is therefore protective of human health and the environment.

Compliance with ARARs. Chemical-specific ARARs associated with this remedial alternative include MTCA Method A industrial cleanup levels for PAHs. The cleanup requirement to protect against direct contact with PAHs is met with this alternative because the material is either removed from the site or covered with two feet of sand and gravel fill material.

Action-specific provisions of the Washington State Dangerous Waste Regulations concerning transportation, storage, and disposal of the waste may apply. Because the briquettes were originally used as a fuel they may likely be considered a product if they are considered a fuel in a burning process. Under these circumstances the Washington State Dangerous Waste Regulations would not apply to burning. Since the PAH-contaminated soil is not removed from the area and groundwater protection is not a cleanup objective, the Washington State Dangerous Waste regulations would be only relevant and appropriate with regard to substantive provisions of the cover design.

Implementability. This alternative will use standard earth moving equipment for site excavation and grading, burning, sand and gravel importing, placing and compaction. Because standard equipment and methods will be used, minimal difficulties or unknowns are associated with construction. The technology is well established and services and materials should be readily available. Difficulties and/or uncertainties may be encountered since a large area of PAH-contaminated soil will be excavated. High groundwater and potential unexpected conditions can also make excavation difficult.

Because of the high organics content of PAH-contaminated soil in some areas it may be very difficult to stabilize/solidify the material. Test sections prior to work will be required to show that the process can be performed as planned and establishing a workable procedure may take time.

Short-Term Effectiveness. The alternative will take a relatively short time to implement with the stabilization portion taking somewhat longer. The risks to the workers during construction are the same as the risks that the alternative is intended

to mitigate. Therefore the overall risk to workers during construction is low provided the institutional controls discussed for the alternative are implemented.

Long-Term Effectiveness. The technologies associated with excavation and filling which will be used are simple and reliable. Given proper and simple maintenance of the sand and gravel cover the alternative will perform as well in the future as it will immediately following construction. Maintenance technologies are also simple and effective. The reliability of cement stabilization over the long-term is not as well determined as technologies using natural earthen materials. The effectiveness of the technology may deteriorate over time.

Reduction of Toxicity, Mobility, or Volume through Treatment. The mobility of the cPAHs left on site and stabilized will be reduced. The toxicity, mobility, and volume of the briquettes will be reduced.

Cost. The cost is approximately \$2,187,715. Refer to Appendix G for a more detailed cost analysis.

Effects on Site Development. There are potential adverse impacts on site development due to the presence of stabilized material which will need to be excavated for placement of utilities and foundations. Heavier equipment will be required for this type of work. The stabilized material should, however, provide excellent subgrade support.

5.6.6 Alternative 6 - Burn Briquettes and Landfill PAH-Contaminated Soil

The key considerations associated with this alternative are:

- ▶ Precludes contact with cPAHs within the charcoal and PAH-contaminated soil and therefore is protective of human health and the environment.
- ▶ All material is removed from the site.
- ▶ The material with the highest concentration of cPAHs is permanently destroyed.
- ▶ The site would be prepared for development.
- ▶ There would be no need for institutional controls for this area.
- ▶ Very high cost.

Overall Protection of Human Health and the Environment. This alternative precludes direct contact with the briquettes as well as the PAH-contaminated soil. As such it meets the cleanup objectives for the site and is therefore protective of human health and the environment.

Compliance with ARARs. Chemical-specific ARARs associated with this remedial alternative include MTCA Method A industrial cleanup levels for PAHs. The cleanup requirement to protect against direct contact with PAHs is met with this alternative because the material is removed from the site.

Action-specific provisions of the Washington State Dangerous Waste Regulations concerning transportation, storage, and disposal of the waste may apply. Because the briquettes were originally used as a fuel they may likely be considered a product if they are considered a fuel in a burning process. Under these circumstances the Washington State Dangerous Waste Regulations would not apply to burning. Since the PAH-contaminated soil is not removed from the area and groundwater protection is not a cleanup objective, the Washington State Dangerous Waste Regulations would only be relevant and appropriate with regard to substantive provisions of the cover design.

Implementability. This alternative will use standard earth moving equipment for site excavation and grading, burning, and sand and gravel importing, placing, and compacting. Because standard equipment and methods will be used, minimal difficulties or unknowns are associated with construction. The technology is well established and services and materials should be readily available.

Short-Term Effectiveness. The alternative will take a relatively short time to implement. The risks to the workers during construction are the same as the risks that the alternative is intended to mitigate. Therefore the overall risk to workers during construction is low provided the institutional controls discussed for the alternative are implemented.

Long-Term Effectiveness. The technologies which will be used are simple and reliable. No maintenance will be required.

Reduction of Toxicity, Mobility, or Volume through Treatment. This alternative reduces the mobility, toxicity, and volume of the briquettes but does not reduce toxicity, mobility, or volume of the PAH-contaminated soil.

Cost. The cost is approximately \$2,167,050. Refer to Appendix G for a more detailed cost analysis.

Effects on Site Development. There will be no adverse impacts to future site development. The sand and gravel backfill will provide excellent support for foundations, pavements, and slabs.

5.6.7 Alternative 7 - Incinerate Briquettes and Cover PAH-Contaminated Soil

Advantages and disadvantages for this alternative are the same as for Alternative 4, "Burn Briquettes/Cover PAH Soil with Sand and Gravel".

The evaluation for Alternative 7 is essentially identical to the discussions for Alternative 4 - Burn the Briquettes/Cover PAH-contaminated Soil with Sand and Gravel. The only substantive difference between the two alternatives is the fact that in Alternative 7 the material will be destroyed in an approved hazardous waste incinerator. This does not change any of the considerations outlined in the evaluation of Alternative 4 with the exception of the cost.

Cost. The cost is approximately \$6,797,579. Refer to Appendix G for a more detailed cost analysis.

5.6.8 Alternative 8 - Incinerate Briquettes and Stabilize PAH-Contaminated Soil

Advantages and disadvantages for this alternative are the same as for Alternative 5—Burn Briquettes/Stabilize PAH-Contaminated Soil.

The evaluation for Alternative 8 is essentially identical to the discussions for Alternative 5—Burn the Briquettes/Stabilize PAH-Contaminated Soil. The only substantive difference between the two alternatives is the fact that in Alternative 8 the material will be destroyed in an approved hazardous waste incinerator. This does not change any of the considerations outlined in the evaluation of Alternative 5 with the exception of the cost.

Cost. The cost is approximately \$7,934,267. Refer to Appendix G for a more detailed cost analysis.

5.6.9 Alternative 9 - Incinerate Briquettes and Landfill PAH-Contaminated Soil

Advantages and disadvantages for this alternative are the same as for Alternative 6—Burn Briquettes/Landfill PAH-Contaminated Soil.

The evaluation for Alternative 9 is essentially identical to the discussions for Alternative 6—Burn Briquettes/Landfill PAH-Contaminated Soil. The only

substantive difference between the two alternatives is the fact that in Alternative 9 the briquettes will be destroyed in an approved hazardous waste incinerator. This does not change any of the considerations outlined in the evaluation of Alternative 6 with the exception of the cost.

Cost. The cost is approximately \$7,913,602. Refer to Appendix G for a more detailed cost analysis.

5.6.10 Alternative 10 - Cap Briquettes with Pavement and Cap PAH-Contaminated Soil with Pavement

The key considerations associated with this alternative are:

- ▶ Precludes contact with cPAHs within the charcoal and PAH-contaminated soil and therefore is protective of human health and the environment.
- ▶ Although groundwater protection is not a cleanup objective, this alternative will help eliminate infiltration of surface water into the material with highest cPAH concentrations.
- ▶ Low cost.
- ▶ The site is prepared for development.
- ▶ Because some PAH contamination would remain on site the need for institutional controls would remain.

Overall Protection of Human Health and the Environment. This alternative precludes direct contact with the briquettes as well as the PAH-contaminated soil. As such it meets the cleanup objectives for the site and is therefore protective of human health and the environment.

Compliance with ARARs. Chemical-specific ARARs associated with this remedial alternative include MTCA Method A industrial cleanup levels for PAHs. The cleanup levels are met because the briquettes and the soil with low concentrations of PAHs are covered with a cap limiting the possibility of human contact with these PAHs.

Because the material will not be removed from the site and because protection of groundwater is not a cleanup objective the Washington State Dangerous Waste

regulations would only be relevant and appropriate with regard to substantive provisions of the cap design.

Implementability. This alternative will use standard earth moving equipment for site grading, sand and gravel importing, placing, and compacting, and cap construction. Because standard equipment and methods will be used, minimal difficulties or unknowns are associated with construction. The technology is well established and services and materials should be readily available.

Short-Term Effectiveness. The alternative will take a relatively short time to implement. The risk to workers during construction is especially low in this case because no material is excavated at the site. The risks to the workers during construction are the same as the risks that the alternative is intended to mitigate. Therefore the overall risk to workers during construction is low provided the institutional controls discussed for the alternative are implemented.

Long-Term Effectiveness. The proposed technologies are simple and reliable. Given proper and simple maintenance of the asphalt cap the alternative will perform as well in the future as it will immediately following construction. Maintenance technologies are also simple and effective.

Reduction of Toxicity, Mobility, or Volume through Treatment. This alternative does not reduce toxicity, mobility, or volume.

Cost. Cost is approximately \$113,493. Refer to Appendix G for a more detailed cost analysis.

Effects on Site Development. With this alternative the site can be used immediately. It also essentially represents the first steps associated with potential long-term development of the site for commercial and/or industrial purposes. It raises the grade of the site as well as provides drainage for future and present development. Placement of sand and gravel fill will provide an excellent subgrade for subsequent paving operations. Repair and maintenance of the protective cover will be simple and cost-effective.

5.7 Comparative Analysis of Alternatives

Briefly as stated before the 10 alternatives are as follows:

- 1) Landfill Briquettes/Cover PAH-Contaminated Soil with Sand and Gravel

- 2) Landfill Briquettes/Stabilize PAH-Contaminated Soil
- 3) Landfill Briquettes/Landfill PAH-Contaminated Soil
- 4) Burn Briquettes/Cover PAH-Contaminated Soil with Sand and Gravel
- 5) Burn Briquettes/Stabilize PAH-Contaminated Soil
- 6) Burn Briquettes/Landfill PAH-Contaminated Soil
- 7) Incinerate Briquettes/Cover PAH-Contaminated Soil with Sand and Gravel
- 8) Incinerate Briquettes/Stabilize PAH-Contaminated Soil
- 9) Incinerate Briquettes/Landfill PAH-Contaminated Soil
- 10) Cap Briquettes with Pavement and Cap PAH-Contaminated Soil with Pavement

Table 5-1 presents a summary of the comparative analyses for the alternatives. In addition to the seven CERCLA evaluation criteria we also evaluated (as discussed in Section 4) future site development compatibility, monitoring requirements, and institutional controls.

5.7.1 Overall Protection of Human Health and the Environment

All of the cleanup objectives are met by each of the alternatives.

Those alternatives which involve removal of material from the site will be more protective locally because the material is eliminated from the site. Those alternatives which contain an element of burning or incineration will be more protective of society as a whole because the material is destroyed.

5.7.2 Compliance with ARARs

All the alternatives either cover, stabilize, or remove the PAH-contaminated material from the site limiting potential for human contact. ARARs are, in effect, complied with for all alternatives.

All action-specific and location-specific ARARs are met pending confirmation that the briquettes are suitable as a fuel.

5.7.3 Implementability

All of the alternatives are feasible. Those alternatives containing "burning of briquettes" will be subject to evaluation of fuel value to determine that the material can be considered a product and not a waste.

Those alternatives containing an element of stabilization will require bench- and pilot-scale treatability testing.

5.7.4 Short-Term Effectiveness

Each alternative with the exception of Alternative 10 requires excavation, handling, and transport of PAH-contaminated material. Consequently all alternatives present some risk to the community and workers. Those alternatives requiring the least amount of "handling" of the material will pose the lowest short-term risk and will be completed in the shortest time frame. Landfilling briquettes and covering PAH-contaminated soil will pose the lowest short-term risk, while burning or incineration of briquettes and stabilization of PAH-contaminated soil will likely have the greatest short-term risk because of increased specialized handling of the materials. A health and safety plan specifically developed for these operations can significantly reduce the risk.

5.7.5 Long-Term Effectiveness

Long-term risks are reduced with all alternatives. Each alternative except Alternatives 3, 6, and 9 result in PAH-contaminated material being left on site although potential for human contact is greatly and satisfactorily reduced.

The technologies, with the exception of stabilization, are all straightforward and proven with a high likelihood of success. Stabilization is a proven technology but some uncertainties exist given the organic nature of the contaminants and the potential effect of the stabilization materials on metals contamination which may be present.

Long-term management, operation, and maintenance for each alternative is minimal.

5.7.6 Reduction of Toxicity, Mobility, or Volume through Treatment

All of the alternatives that involve burning or incineration of the charcoal briquettes result in a reduction of toxicity, mobility, and volume of the PAH-contaminated material because they involve terminal destruction.

5.7.7 Costs

The following is a summary of cost comparisons.

Alternative Estimated Cost

1) Landfill the Charcoal and Cover the PAH-Contaminated Soil	\$555,605
2) Landfill the Charcoal and Stabilize the PAH-Contaminated Soil	\$1,692,294
3) Landfill the Charcoal and Landfill the PAH-Contaminated Soil	\$1,671,629
4) Burn the Charcoal and Cover the PAH-Contaminated Soil	\$1,051,027
5) Burn the Charcoal and Stabilize the PAH-Contaminated Soil	\$2,187,715
6) Burn the Charcoal and Landfill the PAH-Contaminated Soil	\$2,167,050
7) Incinerate the Charcoal and Cover the PAH-Contaminated Soil	\$6,797,579
8) Incinerate the Charcoal and Stabilize the PAH-Contaminated Soil	\$7,934,267
9) Incinerate the Charcoal and Landfill the PAH-Contaminated Soil	\$7,913,602
10) Cap Briquettes with Pavement and Cap PAH-Contaminated Soil with Pavement	\$113,493

5.7.8 Additional Criteria

With regard to the additional three criteria, all alternatives are compatible with future site development. All of the alternatives will call for filling the site with an engineering controlled material. In addition, the existing slag-contaminated soil on site, after initial site grading as part of remediation, will provide excellent subgrade support for both structure foundations and slab and pavement sections.

All alternatives are not likely to require groundwater monitoring.

5.8 Preferred Alternative for PAH-Contaminated Soil

The preferred alternative for the PAH-Contaminated Soil is Alternative 1, Landfill Briquettes/Cover PAH-Contaminated Soil with Sand and Gravel.

All of the alternatives effectively meet the cleanup objectives, are protective, and are in compliance with ARARs.

Because all of the alternatives effectively offer the same level of protection, the choice of preferred alternative is made predominantly on the basis of practicability. Alternative 1 is the most cost-effective of all alternatives and it does effectively mitigate the direct contact, ingestion, and inhalation risks associated with cPAHs on the site.

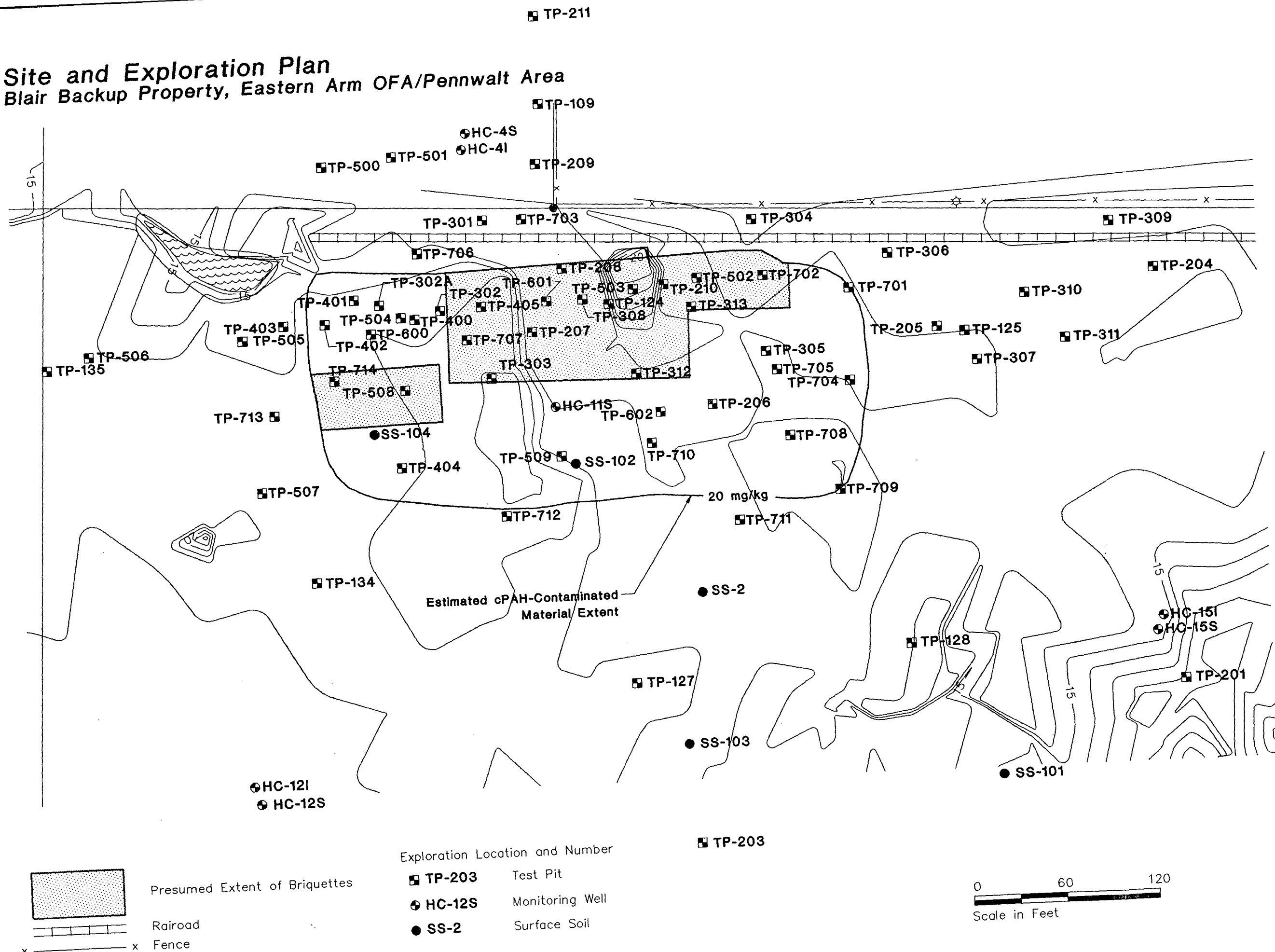
As indicated previously, the practicability of Alternative 1 is dependent on granting classification of the charcoal and charcoal-contaminated soil as solid waste instead of State Dangerous Waste under the Port's Petition for Exemption.

As previously indicated, the preferred alternatives for both the Slag-Contaminated Soil and the PAH-Contaminated Soil will need to be combined into one overall alternative for the OFA/Pennwalt Area.

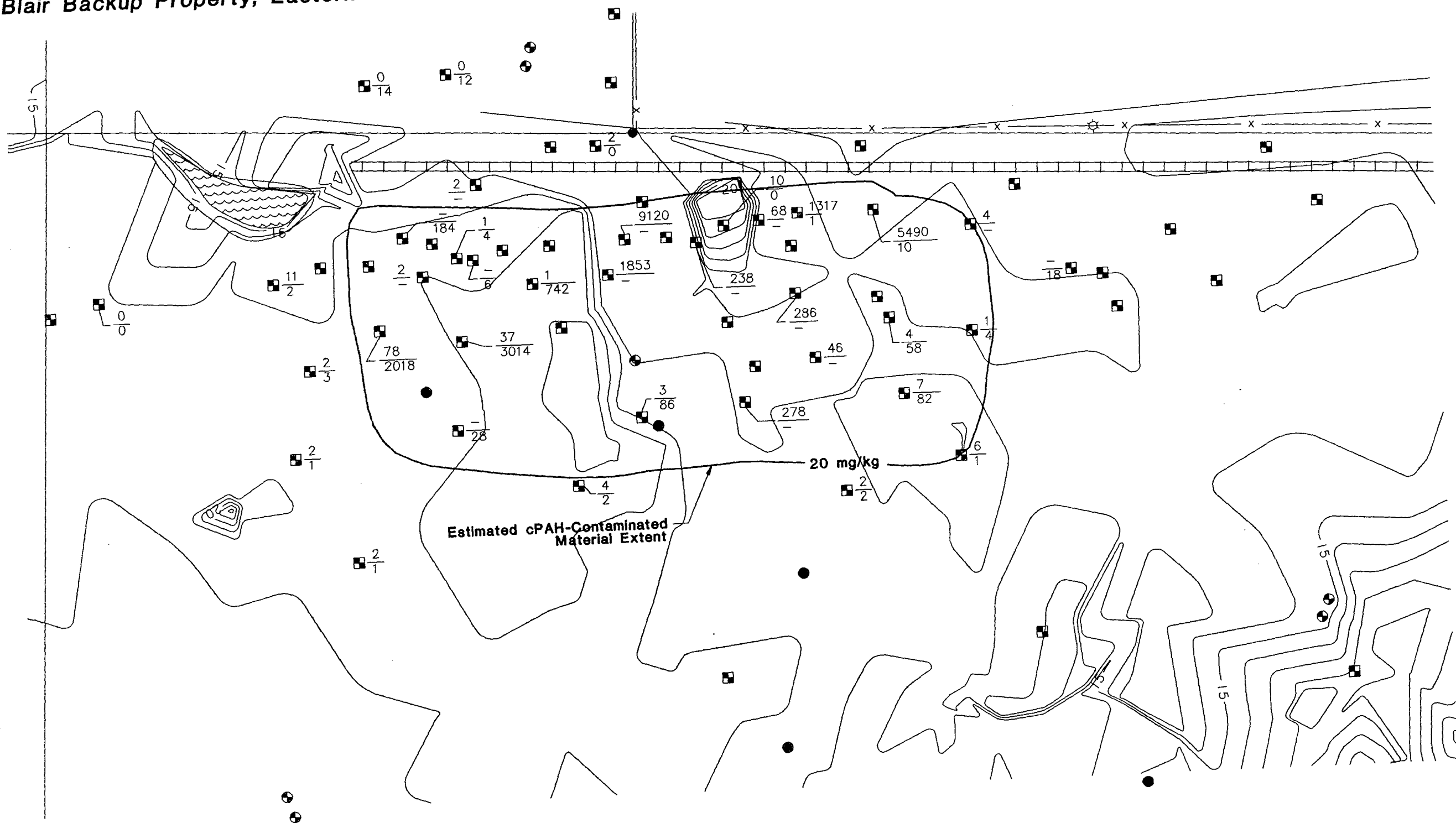
Table 5-1 - OFA/Pennwalt Area - PAH-Contaminated Soil

Alternative Number	Alternative Description	Protectiveness	Comply with ARARs	Reduction of Toxicity, Mobility, or Volume	Long-Term Effectiveness	Implementability	Short-Term Effectiveness	Compatible with Site Development?	Require Monitoring?	Require Institutional Controls?	Estimated Cost
1	Landfill Briquettes - Cover PAH Soil	All cleanup objectives met. Future exposures not likely. Locally protective. Less protective of society (transport).	Yes	Briquettes - Mob Soil - None	Good	Feasible. No admin restrictions. No adverse schedule impacts.	Low risk	Yes	No	H&S Plan for future excavations	\$555,605
2	Landfill Briquettes - Stabilize PAH Soil	All cleanup objectives met. Future exposures not likely. Locally protective. Less protective of society (transport).	Yes	Briquettes - Mob Soil - Mob	Good	Add'l testing req'd. No admin restriction. Adverse schedule impacts.	Moderate risk	Yes	No	H&S Plan for future excavations	\$1,692,294
3	Landfill Briquettes - Landfill PAH Soil	All cleanup objectives met. Future exposures not possible. Locally protective. Less protective of society (transport).	Yes	Briquettes - Mob Soil - Mob	Excellent	Feasible. No admin restrictions. No adverse schedule impacts.	Moderate risk	Yes	No	No	\$1,671,629
4	Burn Briquettes - Cover PAH Soil	All cleanup objectives met. Future exposures not likely. Locally protective. More protective of society.	Yes	Briquettes - Mob, Tox, & Vol Soil - None	Good	Feasible. Possible restrictions. Adverse schedule impacts.	Low risk	Yes	No	H&S Plan for future excavations	\$1,051,027
5	Burn Briquettes - Stabilize PAH Soil	All cleanup objectives met. Future exposures not likely. Locally protective. More protective of society.	Yes	Briquettes - Mob, Tox, & Vol Soil - Mob	Good	Add'l testing req'd. Possible restrictions. Adverse schedule impacts.	Moderate risk	Yes	No	H&S Plan for future excavations	\$2,187,715
6	Burn Briquettes - Landfill PAH Soil	All cleanup objectives met. Future exposures not possible. Locally protective. Less protective of society (transport).	Yes	Briquettes - Mob, Tox, & Vol Soil - Mob	Excellent	Feasible. Possible restrictions. Adverse schedule impacts.	Moderate risk	Yes	No	No	\$2,167,050
7	Incinerate Briquettes - Cover PAH Soil	All cleanup objectives met. Future exposures not likely. Locally protective. More protective of society.	Yes	Briquettes - Mob, Tox, & Vol Soil - None	Good	Feasible. No admin restrictions. No adverse schedule impacts.	Low risk	Yes	No	H&S Plan for future excavations	\$6,797,579
8	Incinerate Briquettes - Stabilize PAH Soil	All cleanup objectives met. Future exposures not likely. Locally protective. More protective of society.	Yes	Briquettes - Mob, Tox, & Vol Soil - Mob	Good	Add'l testing req'd. No admin restrictions. Adverse schedule impacts.	Moderate risk	Yes	No	H&S Plan for future excavations	\$7,934,267
9	Incinerate Briquettes - Landfill PAH Soil	All cleanup objectives met. Future exposures not possible. Locally protective. Less protective of society (transport).	Yes	Briquettes - Mob, Tox, & Vol Soil - Mob	Excellent	Feasible. No admin restrictions. No adverse schedule impacts.	Moderate risk	Yes	No	No	\$7,913,602
10	Cover Briquettes, Cover PAH Soil, Asphalt Cover Area	All cleanup objectives met. Future exposures not likely. Locally protective. More protective of society.	Yes	Mobility	Good	Feasible. No admin restrictions. No adverse schedule impacts.	Low risk	Yes	No	H&S Plan for future excavations	\$113,493






Site and Exploration Plan
Blair Backup Property, Eastern Arm OFA/Pennwalt Area




Site and Exploration Plan Showing Concentrations of cPAHs in Soil
Blair Backup Property, Eastern Arm OFA/Pennwalt Area



Exploration Location and Number

-  Test Pit
 Monitoring Well
 Surface Soil
 cPAH Concentration in mg/kg Shallow Sample
 cPAH Concentration in mg/kg Deep Sample

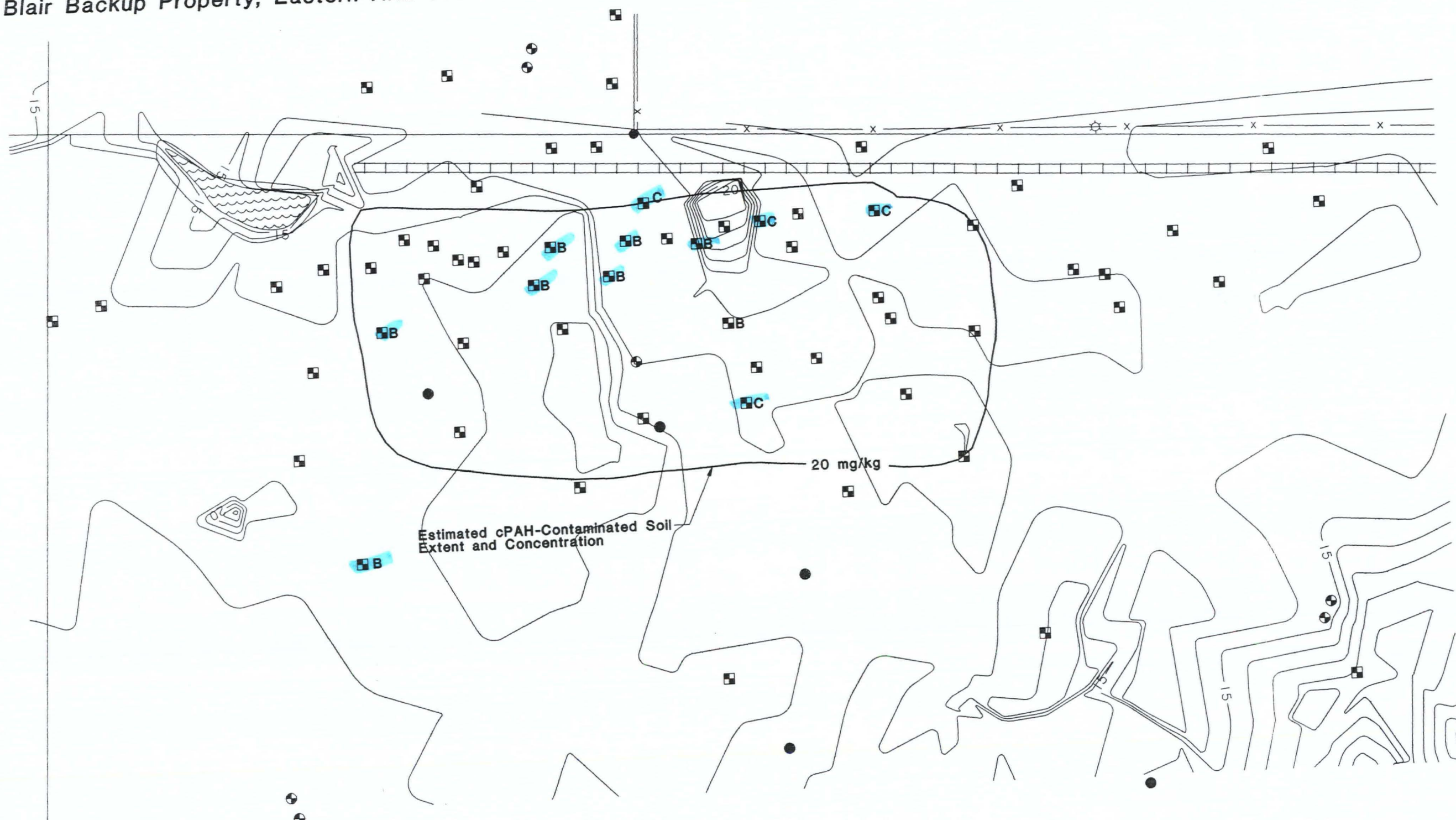

 Railroad
 Fence

0 60 120
Scale in Feet

HARTCROWSER
J-2350-20 3/92
Figure 5-2

Site and Exploration Plan Showing Explorations with Charcoal

Blair Backup Property, Eastern Arm OFA/Pennwalt Area



Exploration Location and Number

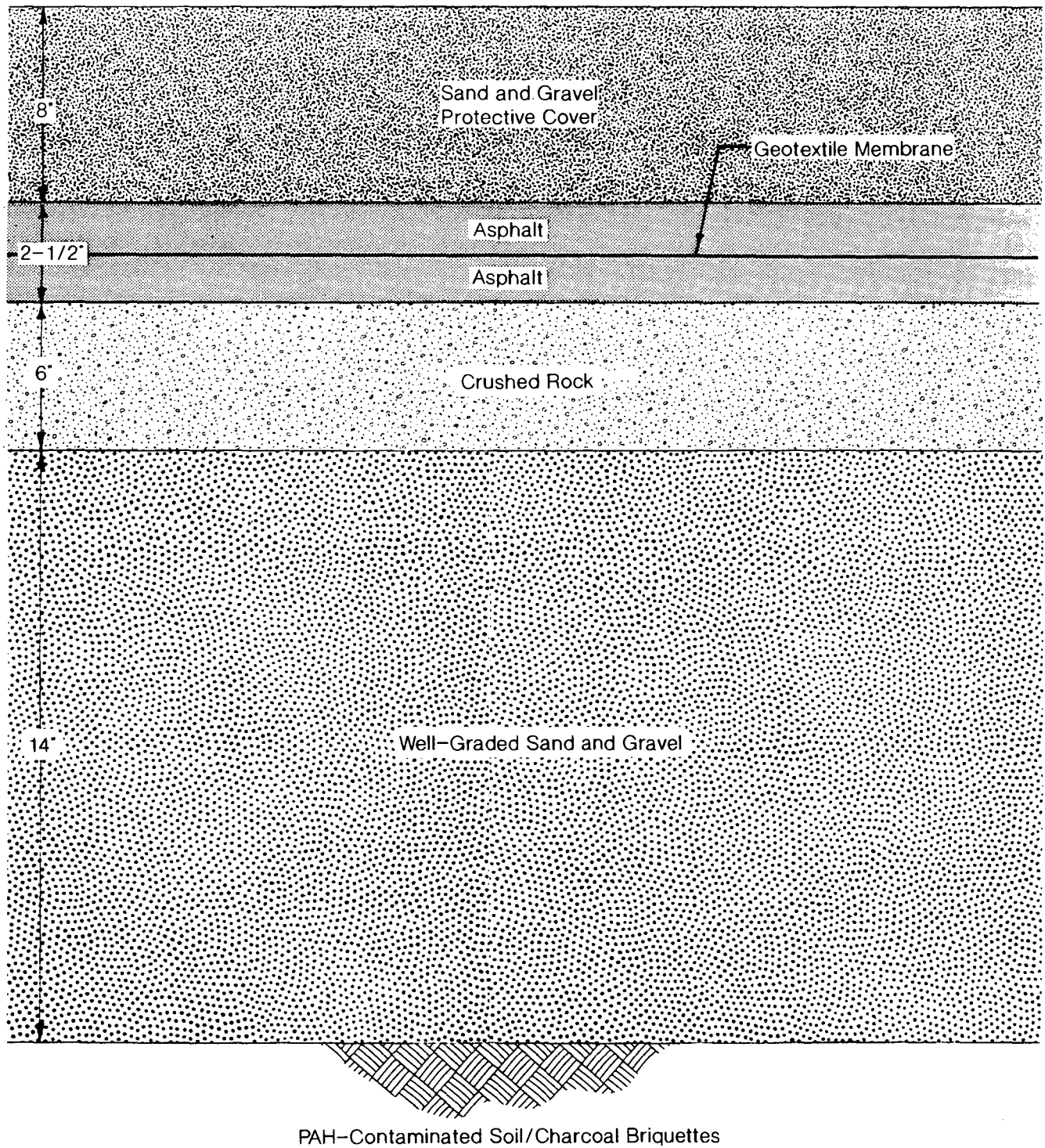
- Test Pit
- Monitoring Well
- Surface Soil
- B Charcoal Briquettes Observed
- C Crushed Charcoal Observed

x x Railroad Fence

0 60 120
Scale in Feet

HARTCROWSER
J-2350-20 3/92
Figure 5-3

Typical Cap Section Alternative 10



Not to Scale



HARTCROWSER

J-2350-20 7/92

Figure 5-4

6.0 EVALUATION OF ALTERNATIVES FOR SANDBLAST GRIT-CONTAMINATED SOIL

6.1 *Inclusion of Sandblast Grit-Contaminated Soil*

Hart Crowser has recently completed excavation of approximately 800 cy of soil contaminated with waste sandblast grit within the North Site Area. Work was accomplished as part of a voluntary cleanup action for the material. The original intent was disposal of what was originally believed to be a very small volume of "nuisance" material in piles at the surface. During excavation it was realized that the extent of the sandblast grit-contaminated soil was far more extensive than originally estimated. Additional layers of sandblast grit and sand and gravel were encountered as excavation was extended below the ground surface. This material is currently stockpiled in two major piles and protected on the site adjacent to the areas of excavation. Smaller piles of excavated material are located along Alexander Avenue on the Blair Backup property.

Analytical testing of the stockpiled material has been performed as part of waste characterization of the material. A summary of this test data is presented in Appendix H. The test data indicate that the material contains elevated concentrations of metals (most notably arsenic) which will preclude it from being disposed of off site as a solid waste. Off-site disposal would likely be required to be at a permitted Dangerous Waste facility. The components of the sandblast grit which are responsible for the elevated metals concentrations are likely Asarco slag which is known to have been recycled for use as sandblast grit.

6.2 *Cleanup Objectives—Human Contact, Surface Water Transport, and Groundwater Protection*

Two cleanup objectives are the same as for the OFA slag/soil. These are:

- ▶ Prevent direct contact; and
- ▶ Prevent slag particulates in surface water.

In addition, the potential consolidation of sandblast grit-contaminated soil in the OFA/Pennwalt Area will require that the proposed remedy also be protective of groundwater quality. Asarco slag is known to leach metals, primarily arsenic, but also lead, copper and zinc. Because of this the selected remedy for the sandblast grit will need to prevent the movement of the slag-associated metals into the groundwater system.

The cleanup objective for groundwater under the combined alternative is to protect groundwater quality by preventing metals leaching from the slag. Since the groundwater in the central slag/soil area of the Blair Backup property currently meets the marine criteria, protection levels (rather than cleanup levels) are proposed. The groundwater cleanup (or protection) standard will be that the groundwater does not show a statistically significant increase in metals following site cleanup.

This cleanup goal meets the MTCA (Chapter 173-340 WAC), Clean Water Act (40 CFR 136), and Washington State Standards for Surface Waters (Chapter 173-201 WAC) identified as chemical-specific ARARs for the site.

A confirmational monitoring program for metals will be developed to verify the performance of the remedy and compliance with the cleanup objective. The point of compliance will be near the property boundaries which will minimize interference with future site uses.

6.3 Development of Cleanup Alternative for Sandblast Grit-Contaminated Soil

The development of cleanup alternatives for the scenario of placing the sandblast grit-contaminated soil on the OFA/Pennwalt Area follows the steps outlined in Sections 4 and 5. The process description will not be repeated here. Refer to Sections 4.3 and 4.4 for discussion.

Again, the "no action" alternative was not considered because in this case it would not be protective of human health and the environment.

We have formulated three alternatives for consideration of the sandblast grit-contaminated soil. Since these materials are already excavated and stockpiled on the property, these alternatives would involve:

- ▶ **Landfill**
- ▶ **Place in OFA/Pennwalt Area**
- ▶ **Stabilize and Place in OFA/Pennwalt Area**
- ▶ **Recycle Sandblast Grit**

Each alternative is described below.

6.3.1 Alternative 1 - Landfill Sandblast Grit-Contaminated Soil

This alternative consists of removal of the sandblast grit-contaminated soil from the site. The material would be transported to a permitted Dangerous Waste landfill. The existing excavations will be backfilled and regraded.

Institutional controls would not be necessary.

No groundwater or surface water monitoring would be required.

6.3.2 Alternative 2 - Place Sandblast Grit-Contaminated Soil in OFA/Pennwalt Area

This alternative consists of placement of the material in a small consolidated area within the OFA/Pennwalt Area followed by placement of a low permeability cap consisting of two layers of asphalt and an oil impregnated geotextile membrane. The area would be graded to about elevation 15.5 feet. A minimum six-inch lift of imported sand and gravel would then be placed prior to placement of the sandblast grit-contaminated soil to ensure grit soil is placed above the high groundwater level at the site, and to preclude contact with wood debris on the site. The sandblast grit-contaminated soil would then be placed and compacted in a 20- to 24-inch layer, followed by construction of the crushed rock and asphalt cap. The cap would be covered with a protective layer of sand and gravel fill or crushed rock. The containment area would be small, about 120 feet by 120 feet in dimension.

The existing excavations for the grit removal will be backfilled and regraded.

The exact placement of material can be adjusted based on long-term development plans for the site such that it minimizes interference with site development. A likely location for placement would be immediately adjacent to the PAH-contaminated area. Since the cover for both the PAH cleanup and the grit-contaminated soil are identical it makes sense to combine the cleanup in one area. This area is also toward the side of the property where it is least likely to interfere with future development.

The location of the construction is shown on Figure 6-1 along with the locations of the preferred alternatives for the OFA slag/soil and PAH-contaminated material.

Institutional controls would include:

- ▶ Restricting use of groundwater from the shallow and intermediate aquifer at the site for use as drinking water

- ▶ Require that health and safety plans and provisions be used during future subsurface work at the site that may expose workers to the slag-contaminated soil and require that personnel involved with subsurface work should be health and safety trained
- ▶ Provide appropriate notification to current and future owners and tenants as well as persons engaged in pertinent on site activities

Groundwater monitoring would be required.

6.3.3 Stabilize Sandblast Grit-Contaminated Soil in OFA/Pennwalt Area

This alternative would be identical to the preceding Alternative 2 with the exception that the grit would be stabilized prior to placement within the OFA/Pennwalt Area.

The solidification/stabilization process will consist of the addition of Portland cement and other materials (based on treatability testing) to the sandblast grit-contaminated soil. Cement would be added in the range of 3 to 12 percent in order to create a compacted soil-cement. The soil would probably require screening and crushing of large particles; the crushed particles would be added back to the soil mix. The processed mix of soil and cement would be designed to provide relatively low permeability, good strength, compactibility, and adequate pH control. Additives may be added, if necessary, to reduce shrinkage upon curing. Detailed bench- and pilot-scale treatability testing would be required to implement this alternative.

Institutional controls would be the same as for Alternative 2.

Groundwater monitoring would be required.

6.3.4 Alternative 4 - Recycle Sandblast Grit-Contaminated Soil

This alternative consists of removal of the sandblast grit-contaminated soil from the site. The material would be removed to the Holnam Cement facility and used in lieu of a portion of the normal feed stock in the cement manufacturing process. The existing excavations would be backfilled and regraded. Institutional controls would not be necessary.

No groundwater or surface water monitoring would be required.

6.4 Evaluation of Alternatives

This section presents a discussion of the three alternatives considered for remediating the sandblast grit-contaminated soil in the North Site Area.

6.4.1 Alternative 1 - Landfill Sandblast Grit-Contaminated Soil

The key considerations associated with this alternative include:

- ▶ Precludes contact with sandblast grit-contaminated soils, protective of groundwater, and will preclude runoff of particulates. It therefore meets cleanup objectives and is protective of human health and the environment.
- ▶ The material is removed from the property.
- ▶ Institutional controls for the site will not be required.
- ▶ High cost.

Overall Protection of Human Health and the Environment. This alternative precludes direct contact, ingestion, and inhalation of the sandblast grit-contaminated soil. It also will preclude migration of grit particulates from the site. It will also be protective of groundwater quality. As such it meets the cleanup objectives for the site and is therefore protective of human health and the environment.

Compliance with ARARs. Chemical-specific ARARs associated with the remedial alternative include MTCA Method A industrial cleanup levels for arsenic, copper, lead, and zinc. The metals ARARs are met with this alternative because the material is removed from the site.

Action-specific provisions of the Washington State Dangerous Waste Regulations concerning transportation, storage, and disposal of the waste would apply based on Ecology's current state only dangerous waste classification of arsenic. These ARARs will determine the appropriate disposal method and location of the excavated material.

Implementability. This alternative will use standard earth moving equipment for site excavation and grading, and sand and gravel importing, placing, and compacting. Because standard equipment and methods will be used, minimal difficulties or unknowns are associated with construction. No long-term maintenance will be required.

This technology is well established. Required services and materials should be readily available.

Short-Term Effectiveness. The alternative will take a relatively short time to implement. The risks to the workers during construction are the same as the risks that the alternative is intended to mitigate. Therefore the overall risk to workers during construction is low provided the institutional controls discussed for the alternative are implemented.

Long-Term Effectiveness. The technologies which will be used are simple and reliable.

Reduction of Toxicity, Mobility, or Volume through Treatment. This alternative does not reduce toxicity, mobility, or volume.

Cost. Cost is approximately \$499,416.

Effects on Site Development. There will be no adverse effects on site development because the contaminants will be removed from the site and no maintenance is required.

6.4.2 Alternative 2 - Place Sandblast Grit-Contaminated Soil in OFA/Pennwalt Area

The key considerations associated with this alternative are:

- ▶ Precludes contact with sandblast grit-contaminated soil, precludes particulates in runoff and is protective of groundwater and therefore is protective of human health and the environment.
- ▶ Low cost.
- ▶ The site is prepared for development.
- ▶ Because some grit associated contamination would remain on site the need for institutional controls would remain.
- ▶ Grit contamination would remain on site.

Overall Protection of Human Health and the Environment. This alternative precludes direct contact with the grit, precludes particulates in runoff, and is protective of groundwater. Direct contact is precluded because the material will be

covered with sand and gravel fill as well as a "hardened" surface. The hardened surface will also function as a low permeability barrier to minimize infiltration and eliminate arsenic or arsenic particulates in runoff from the site. The sandblast grit is presently thoroughly mixed with silty sand and gravel. This material will be thoroughly compacted as it is placed on site such that the permeability of the material will be greatly lessened, further reducing the potential for infiltration. The results of TCLP testing presented in Appendix H indicate a very low potential for leaching of the material. Based on these considerations the potential for adverse impacts to surface water and groundwater is effectively eliminated. As such it meets the cleanup objectives for the site and is therefore protective of human health and the environment.

Compliance with ARARs. Chemical-specific ARARs associated with this remedial alternative include MTCA Method A industrial cleanup levels for arsenic, copper, lead, and zinc. The cleanup levels are met because the sandblast grit-contaminated soil is covered with a cap that limits the possibility of human contact and protects groundwater quality.

The material will not be removed from the site. Protection of groundwater quality is a cleanup objective. Therefore the Washington State Dangerous Waste Regulations would only be relevant and appropriate with regard to the substantive provisions of the cap design.

Implementability. This alternative will use standard earth moving equipment for site grading, sand and gravel importing, placing, and compacting, and cap construction. Because standard equipment and methods will be used, minimal difficulties or unknowns are associated with construction. The technology is well established and services and materials should be readily available.

Short-Term Effectiveness. The alternative will take a relatively short time to implement. The risks to the workers during construction are the same as the risks that the alternative is intended to mitigate. Therefore the overall risk to workers during construction is low provided the institutional controls discussed for the alternative are implemented.

Long-Term Effectiveness. The proposed technologies are simple and reliable. Given proper and simple maintenance of the asphalt cap the alternative will perform as well in the future as it will immediately following construction. Maintenance technologies are also simple and effective.

Reduction of Toxicity, Mobility, or Volume through Treatment. This alternative does not reduce toxicity, mobility, or volume.

Cost. Cost is approximately \$31,500. Refer to Appendix G for a more detailed cost analysis.

Effects on Site Development. With this alternative the site can be used immediately. It raises the grade of the site as well as provides drainage for future and present development. Placement of sand and gravel fill will provide an excellent subgrade for subsequent paving operations. Repair and maintenance of the pavement will be simple and cost-effective.

6.4.3 Alternative 3 - Stabilize Sandblast Grit-Contaminated Soil in OFA/Pennwalt Area

The key considerations associated with this alternative are:

- ▶ Precludes contact with sandblast grit-contaminated soil, precludes particulates in runoff and is protective of groundwater and therefore is protective of human health and the environment.
- ▶ High cost.
- ▶ The site is prepared for development.
- ▶ Because some grit associated contamination would remain on site the need for institutional controls would remain.
- ▶ Given the low levels of metals in the grit-contaminated soil the marginal benefit of the technology is low relative to cost.

Overall Protection of Human Health and the Environment. This alternative precludes direct contact with the grit, precludes particulates in runoff, and is protective of groundwater. As such it meets the cleanup objectives for the site and is therefore protective of human health and the environment.

Compliance with ARARs. Chemical-specific ARARs associated with this remedial alternative include MTCA Method A industrial cleanup levels for arsenic, lead, copper, and zinc. The cleanup levels are met because the sandblast grit-contaminated soil covered with a cap that limits the possibility of human contact with the PAHs, and protects groundwater quality.

The material will not be removed from the site and protection of groundwater quality is a cleanup objective. Therefore the Washington State Dangerous Waste Regulations would only be relevant and appropriate with regard to the substantive provisions of the cap design.

Implementability. This alternative will use standard earth moving equipment for site grading, sand and gravel importing, placing and compaction, and cap construction. Because standard equipment and methods will be used, minimal difficulties or unknowns are associated with construction. The technology is well established and services and materials should be readily available.

With regard to stabilization, bench and pilot treatability studies as well as a test section prior to work will be required to show that the process can be performed as planned. Establishing a workable procedure may take time.

Short-Term Effectiveness. The alternative will take a longer time frame to implement. The risks to the workers during construction are the same as the risks that the alternative is intended to mitigate. Therefore the overall risk to workers during construction is low provided the institutional controls discussed for the alternative are implemented.

Long-Term Effectiveness. The proposed technologies are simple and reliable. Given proper and simple maintenance of the asphalt cap the alternative will perform as well in the future as it will immediately following construction. Maintenance technologies are also simple and effective.

The reliability of cement stabilization over the long-term is not as well documented as using natural earthen materials. The effectiveness of the alternative may deteriorate over time.

Reduction of Toxicity, Mobility, or Volume through Treatment. This alternative reduces mobility of all constituents.

Cost. Cost is approximately \$201,826. Refer to Appendix G for a more detailed cost analysis.

Effects on Site Development. With this alternative the site can be used immediately. It raises the grade of the site as well as provides drainage for future and present development. Placement of sand and gravel fill will provide an excellent subgrade for subsequent paving operations. Repair and maintenance of the protective cover will be simple and cost-effective.

6.4.4 Alternative 4 - Remove and Recycle Sandblast Grit-Contaminated Soil

The key considerations associated with this alternatives are:

- ▶ Precludes long-term human contact and environmental exposure at the site; potential for off-site human and environmental exposure depending on use and integrity of material.
- ▶ Moderately high cost.
- ▶ The site is prepared for development.

Overall Protection of Human Health and the Environment. This alternative addresses long-term issues at the site as it precludes direct contact with the grit, precludes particulates in runoff, and is protective of site groundwater. As such it meets cleanup objectives for the site. Removal and recycling of material as an ingredient in cement for pavement or building materials involves potential contact during transportation, storage, and handling of material. Depending on the long-term use of the cement and its integrity, the potential exists for future human or environmental exposure to contaminants.

Compliance with ARARs. Chemical-specific ARARs associated with this alternative include MTCA Method A industrial cleanup levels for arsenic, copper, lead, and zinc. The cleanup levels are met at the site as it precludes direct contact, precludes particulates in surface water, and is protective of groundwater.

Action-specific provisions of the Washington State Dangerous Waste Regulations concerning transportation, storage, and application and reuse of the recycled material may apply.

Implementability. This alternative will use standard earth-moving equipment for site excavation. No long-term maintenance at the site is required. The technology for recycling is well established.

Short-Term Effectiveness. This alternative will take a relatively short time to implement. The risks to workers is slightly higher than the risk that the alternative is intended to mitigate during handling and recycling, but can be effectively reduced by observing proper health and safety handling procedures.

Long-Term Effectiveness. The proposed technology is simple. Long-term reliability is expected to be good; however, long-term effectiveness could be reduced depending on application, use, environmental factors, and integrity of the material.

Reduction of Toxicity, Mobility, or Volume through Treatment. This alternative reduces the mobility of the contaminants, but does not reduce the toxicity or volume.

Cost. Cost is approximately \$80,000.

Effects on Site Development. With this alternative, the site can be used immediately.

6.5 *Comparative Analysis of Alternatives*

This section presents and evaluates cleanup alternatives for the sandblast grit contaminated soil.

6.5.1 Overall Protection

Each of the alternatives is protective of human health and the environment.

6.5.2 Compliance with ARARs

All of the alternatives either cap, stabilize, or remove the sandblast grit-contaminated soil which will prevent human contact and provide groundwater protection at the site. ARARs are in effect complied with for all alternatives. Action- and location-specific ARARs can be met with all alternatives, assuming that the recycling facility need not be a permitted TSD facility.

6.5.3 Implementability

Alternatives 1, 2, and 4 are the most easily implemented of the alternatives. Alternative 3 is somewhat more problematic in that additional testing of the stabilization technology will be required.

6.5.4 Short-Term Effectiveness

Alternatives 3 and 4 offer the greatest short-term risk to workers in that a greater amount of handling of the material will be required.

6.5.5 Long-Term Effectiveness

Alternative 1 has the greatest potential for long-term effectiveness simply because the material is removed from the site and secured in a hazardous waste landfill. The potential failure of the system is low for all alternatives with Alternative 3 having a slightly higher failure potential. This is due to the uncertainty of treating the sandblast grit-contaminated soil.

6.5.6 Reduction of Toxicity, Mobility, or Volume through Treatment

Alternatives 3 and 4 directly reduces the mobility of the metals in the grit-contaminated soil.

6.5.7 Cost

The following is a summary of cost comparisons.

1) Landfill	\$499,416
2) Place in OFA/Pennwalt Area	\$31,500
3) Stabilize and Place in OFA/Pennwalt Area	\$201,826
4) Recycle as Portland Cement	\$80,000

6.5.8 Effects on Site Development

With regard to the additional three criteria, all alternatives are compatible with future site development. All of the alternatives will call for filling the site with an engineering controlled material. In addition, the sandblast grit-contaminated soil, if left on site will provide excellent subgrade support for both structure foundations and slab and pavement sections.

6.6 Preferred Alternative for Sandblast Grit-Contaminated Soil

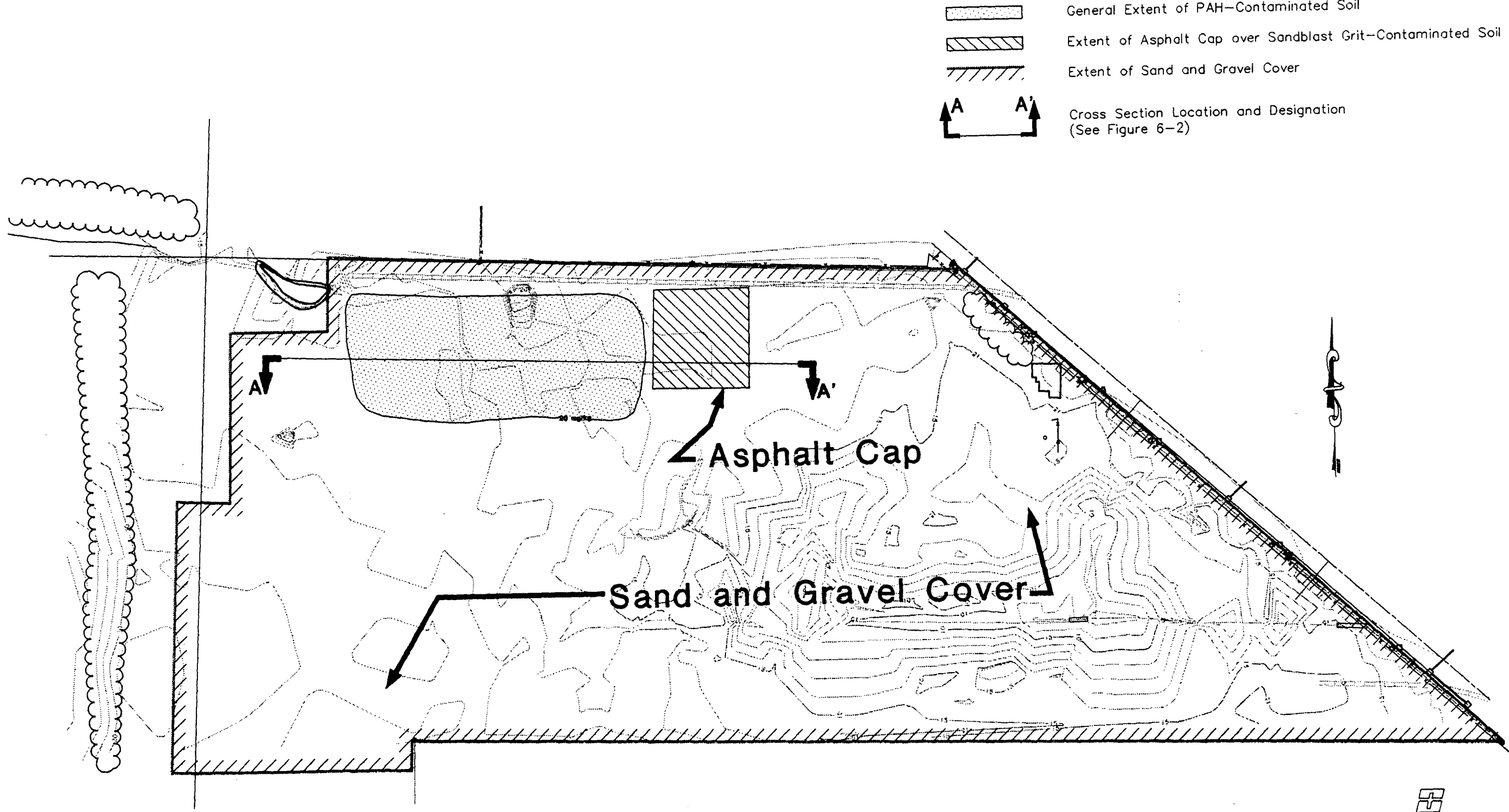
The preferred alternative for the sandblast grit-contaminated soil is Alternative 2, Place Sandblast Grit-Contaminated Soil in OFA/Pennwalt Area. Grit-contaminated soil would be placed above the groundwater table on sand and gravel and capped with asphalt concrete pavement with a geotextile membrane, isolating material from surface water infiltration. Sandblast grit is 5 to 10 percent of total soil mixture mass and would be compacted to further reduce infiltration. Long-term management of sandblast grit soil (1,000 cy) would be accomplished in concert with management of Blair Waterway property Asarco slag to be placed within a 7-acre area of the OFA/Pennwalt Area as described in Section 8.

All of the alternatives effectively meet the cleanup objectives, are protective, and are in compliance with ARARs.

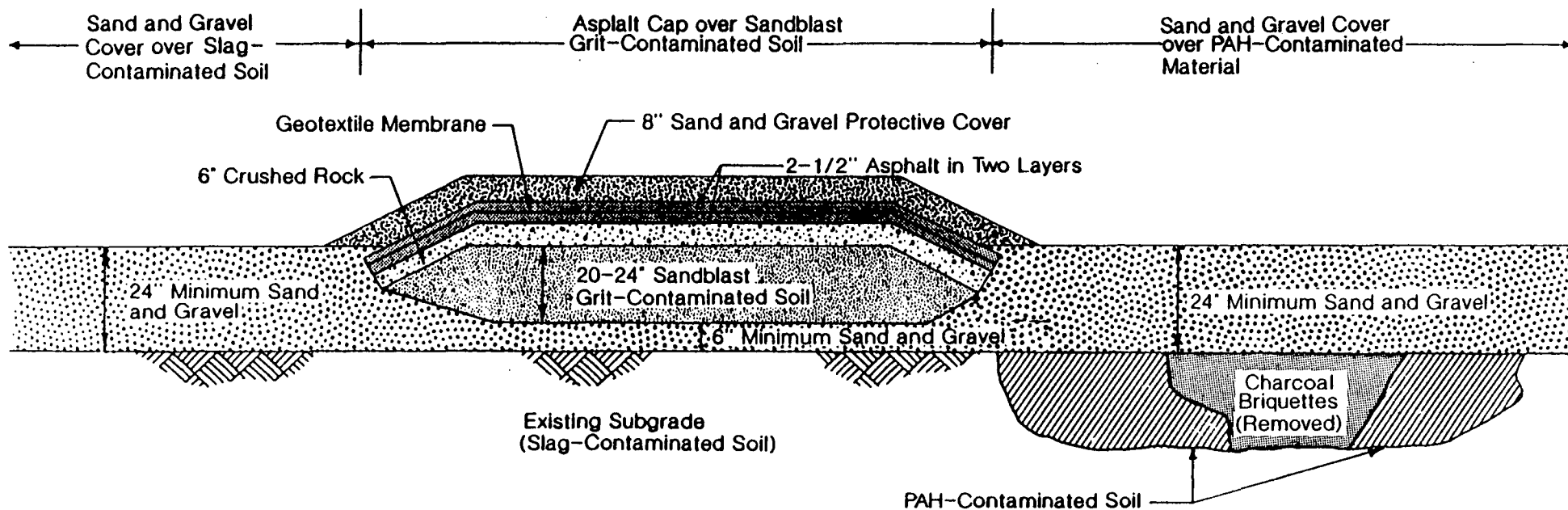
All alternatives, including the preferred alternative are protective of Human Health and the Environment at the site in that direct contact and surface water transport are prevented and groundwater is protected. Alternative 3 (Stabilize Sandblast Grit-Contaminated Soil in OFA/Pennwalt Area) and Alternative 1 (Landfill) are eliminated because any increase in protectiveness over the Preferred Alternative is not substantiated by the order of magnitude increase in cost, i.e., these alternatives are not cost-effective.

Plan Showing Intended Location of Sandblast Grit-Contaminated Soil

Blair Backup Property, Eastern Arm, OFA/Pennwalt Area



Typical Section A-A' through Cover and Asphalt Cap



Not to Scale

7.0 COMBINING THE ALTERNATIVES FOR THE BLAIR BACKUP PROPERTY

This section evaluates the preferred combination of cleanup alternatives for the Blair Backup property. Alternatives address the OFA slag, the OFA Ditch surface water, PAH- and sandblast grit-contaminated material discussed, respectively, in Sections 4, 5, and 6.

The preferred alternatives consist of:

- ▶ Grading, filling, and draining the entire OFA/Pennwalt Area including the area of PAH contamination. Filling will be done using clean select pit run sand and gravel (Alternative 3 for OFA Slag/Soil).
- ▶ Subsequent to grading and filling, the charcoal and charcoal-contaminated soil will be removed and the PAH-contaminated area will be covered (Alternative 1 for PAH-Contaminated Material).
- ▶ Place sandblast grit-contaminated soil in the OFA/Pennwalt Area adjacent to the PAH-contaminated soil (Alternative 2 for the Sandblast Grit-Contaminated Soil)

Figure 7-1 presents a Site Plan showing the overall extent of grading, filling, and drainage. A schematic cross section through all areas is presented on Figure 7-2.

The sequence of construction would be as follows:

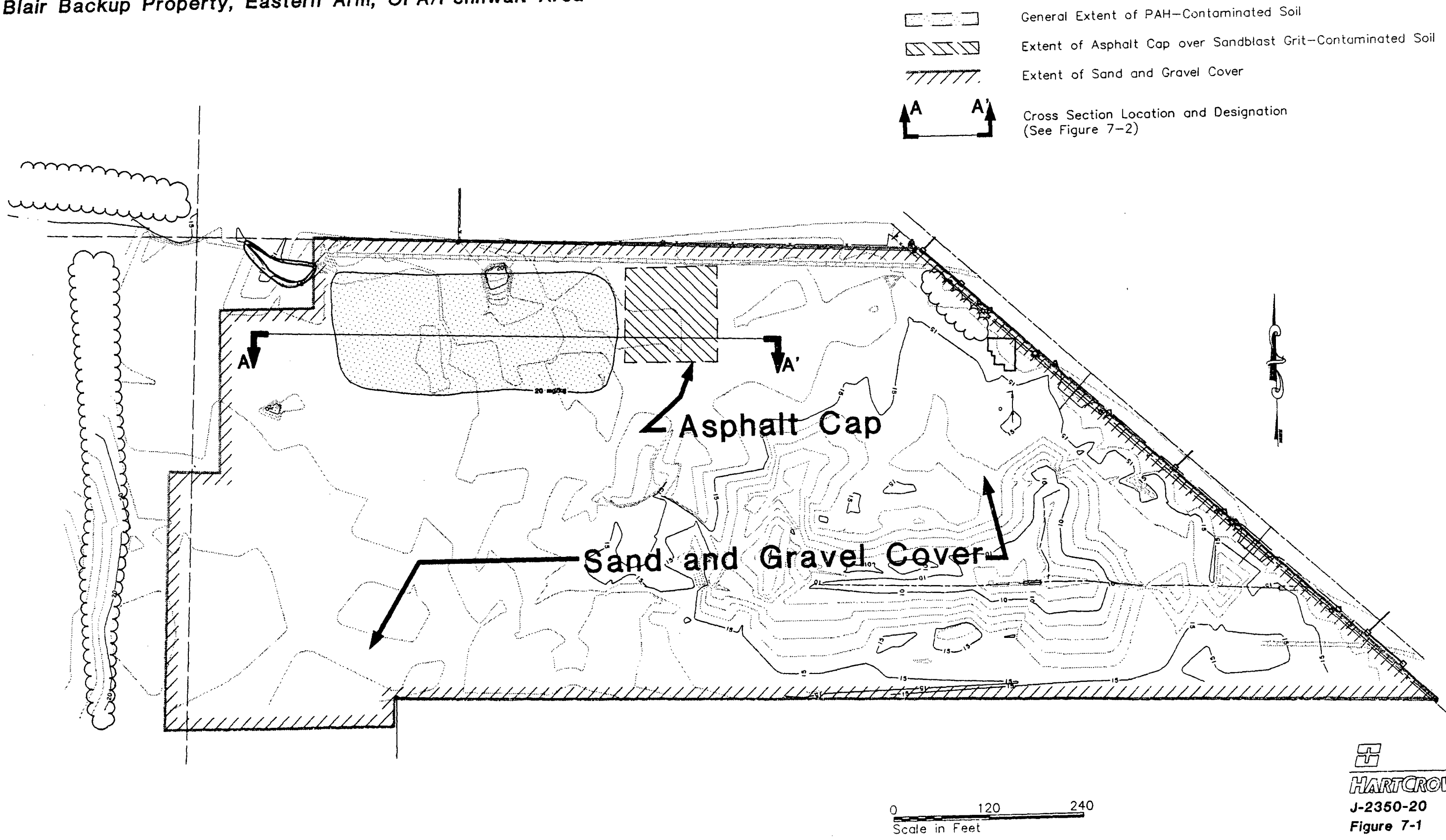
- ▶ Remove stockpiled wood debris to one corner of the site.
- ▶ Grade site to parallel final design site elevations. This will result in an overall average site grade of about elevation 15.5 feet.
- ▶ Excavate and remove charcoal briquettes and charcoal-contaminated soil from the site.
- ▶ Distribute the stockpiled wood debris in a thin lift across the graded site. Large pieces of debris would be either placed around the perimeter of the site (non-critical, non-structural areas) so as not to interfere with future site development or would be removed from the site. The remaining debris would result in a lift of material of about two inches across the entire site.

- ▶ Place and compact 24 inches of sand and gravel across the site. This material will likely consist of a well-graded sand and gravel material with less than five percent fines (material passing a U.S. No. 200 sieve). The material would be placed in two 12-inch lifts and compacted to a dense non-yielding condition corresponding to 95 percent of the Modified Proctor dry density in order to facilitate future construction of foundations and pavements as part of eventual site development.
- ▶ Place sandblast grit-contaminated soil on the site in a 20- to 24-inch layer.
- ▶ Construct drainage trenches along the north, south, and east property lines as shown on Figure 7-1.
- ▶ Place and compact six inches of crushed rock base course in the area shown on Figure 7-2.
- ▶ Overlay the crushed rock with two lifts of asphalt including an intermediate layering of impregnated geotextile as a membrane.

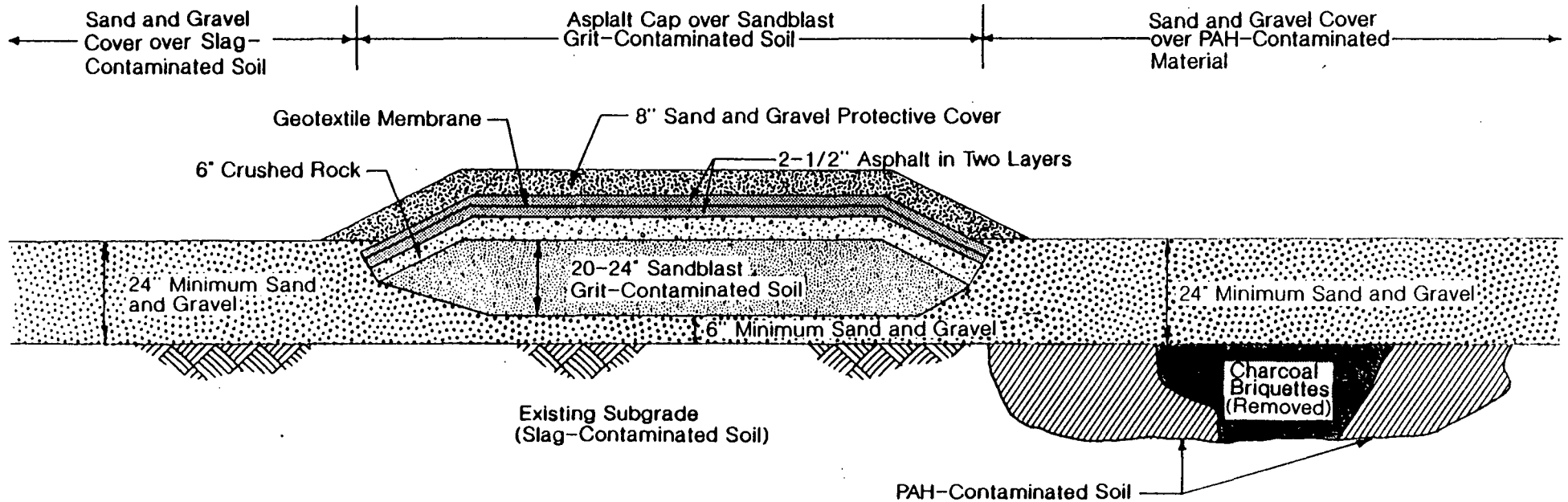
As part of any of the above scenarios groundwater monitoring would be conducted to monitor performance of the system. We anticipate that groundwater sampling will occur twice yearly for a period of five years.

The total cost for the assembled alternative is approximately \$1,434,323 (refer to Appendix G).

Plan Showing Assembled Alternatives for Slag-, PAH-, and Sandblast Grit-Contaminated Soil
Blair Backup Property, Eastern Arm, OFA/Pennwalt Area



Typical Section A-A' through Cover and Asphalt Cap



Not to Scale

8.0 RECOMMENDED ALTERNATIVE FOR COMBINED BLAIR PROPERTIES CLEANUP

8.1 *Description of Option Components*

This section investigates the feasibility of placing Asarco slag-contaminated material and ditch sediments from the Blair Waterway property onto the OFA/Pennwalt Area of the Blair Backup property.

Material from the Blair Waterway property would include approximately 18,000 cy of mixed Asarco slag and soil, and about 80 cy of Weyerhaeuser Ditch sediments. Arsenic is the contaminant of concern for all of these materials. One of the Preferred Alternatives include removal of this material and its placement within the Blair Backup property OFA/Pennwalt Area. Refer to the Analysis of Alternatives prepared by Landau Associates (1992) for discussion of Blair Waterway property alternatives.

The exact placement of Blair Waterway material within the OFA/Pennwalt Area can be adjusted based on convenience and appropriateness with the long-term development plans for the site such that it minimizes interference with site development. There are two options for placement of this material in the OFA/Pennwalt Area.

8.1.1 Option A

Option A would consist of placing the slag material over the entire 17-acre OFA/Pennwalt Area as shown on Figure 8-1.

A cross section through the fill and cover for this alternative is presented on Figure 8-2. Under this alternative the site would be cut and filled to achieve the appropriate grades for drainage. This will result in an average site grade of about elevation 15.5 feet. A minimum 6-inch thickness of clean, well-graded sand and gravel will be placed over the prepared subgrade followed by placement of the slag. The purpose of the 6-inch sand and gravel layer is to raise the bottom elevation of the slag such that it will be above the anticipated high groundwater level and will not be in contact with the remnants of wood debris left on the site at a lower elevation. Based on current volume estimates this will result in a 8- to 9-inch thickness of slag and grit over the entire 17 acres. The slag and grit will then be covered with a low permeability cover/pavement section which has been previously described in Alternative 10 for the PAH-contaminated soil.

The cost for Option A would be \$2,514,891.

8.1.2 Option B

Option B consolidates the slag and ditch sediments in a smaller area. To minimize adverse impacts to future site development we have limited the overall height of the confinement system to three feet above the graded site. This results in about 21 inches of slag and grit placed over a seven-acre area as shown on Figure 8-3. For purposes of this discussion we have placed the material in the western portion of the OFA/Pennwalt Area to better match the higher grades to the west. Figure 8-4 shows a cross section of the proposed fill and cover system in relation to the remainder of the site assuming implementation of the preferred cleanup alternatives outlined in Section 4 for the OFA slag/soil (Alternative 3, Section 4.6.3).

The cost for Option B would be \$1,899,720.

Groundwater monitoring would be conducted to monitor performance of the system for both Options A and B. We anticipate that groundwater sampling will occur twice yearly for a period of two to five years.

Institutional controls would include:

- ▶ Restricting use of groundwater from the shallow and intermediate aquifer at the site for use as drinking water
- ▶ Require that health and safety plans and provisions be observed during future subsurface work at the site that may expose workers to the slag-contaminated soil and ditch sediments and grit-contaminated soil and require that personnel involved with subsurface work should be health and safety trained
- ▶ Provide appropriate notification to current and future owners and tenants as well as persons engaged in pertinent on site activities

8.2 Evaluation of the Alternative

The "combined alternative" of placing the Blair Waterway property slag and ditch sediments, and Blair Backup property sandblast grit-contaminated soil in the OFA/Pennwalt Area of the Blair Backup property is a preferred alternative. The cleanup objectives for placement of the Blair Waterway materials on the Blair Backup property will be the same as for the grit-contaminated soil, including:

- ▶ Prevent direct contact;
- ▶ Prevent migration of slag particulates in surface water runoff; and
- ▶ Protect groundwater quality.

Implementation of Options A or B described above is consistent with the analyses and recommendations in the Blair Waterway Property Analysis of Alternatives. The evaluation of Options A and B above with regard to the pertinent CERCLA criteria would be the same and will not be repeated here.

In summary, the combining of cleanup actions for the Blair Backup property and the Blair Waterway property is preferred for the following reasons:

- ▶ All contaminated soil is combined within one area thus limiting long-term management requirements including effective implementation of monitoring and institutional controls;
- ▶ It poses less potential for environmental impact because it is further removed from the waterways than disposal on the Blair Waterway property, and limited pathways for contaminant transport to surface water bodies exist internal to the Blair Backup property;
- ▶ All cleanup objectives can be met;
- ▶ It facilitates unrestricted development for the major extent of the Blair properties.

The preferred option is to consolidate the material within a seven-acre scenario as depicted in Option B for reasons of cost and long-term management.

8.3 Cost for Combined Blair Properties Cleanup

Table 8-1 presents a summary of the costs of combined cleanup of the Blair Waterway property and the Blair Backup property.

Table 8-1 Preferred Options Cost Summary for Combined Blair Property Cleanup

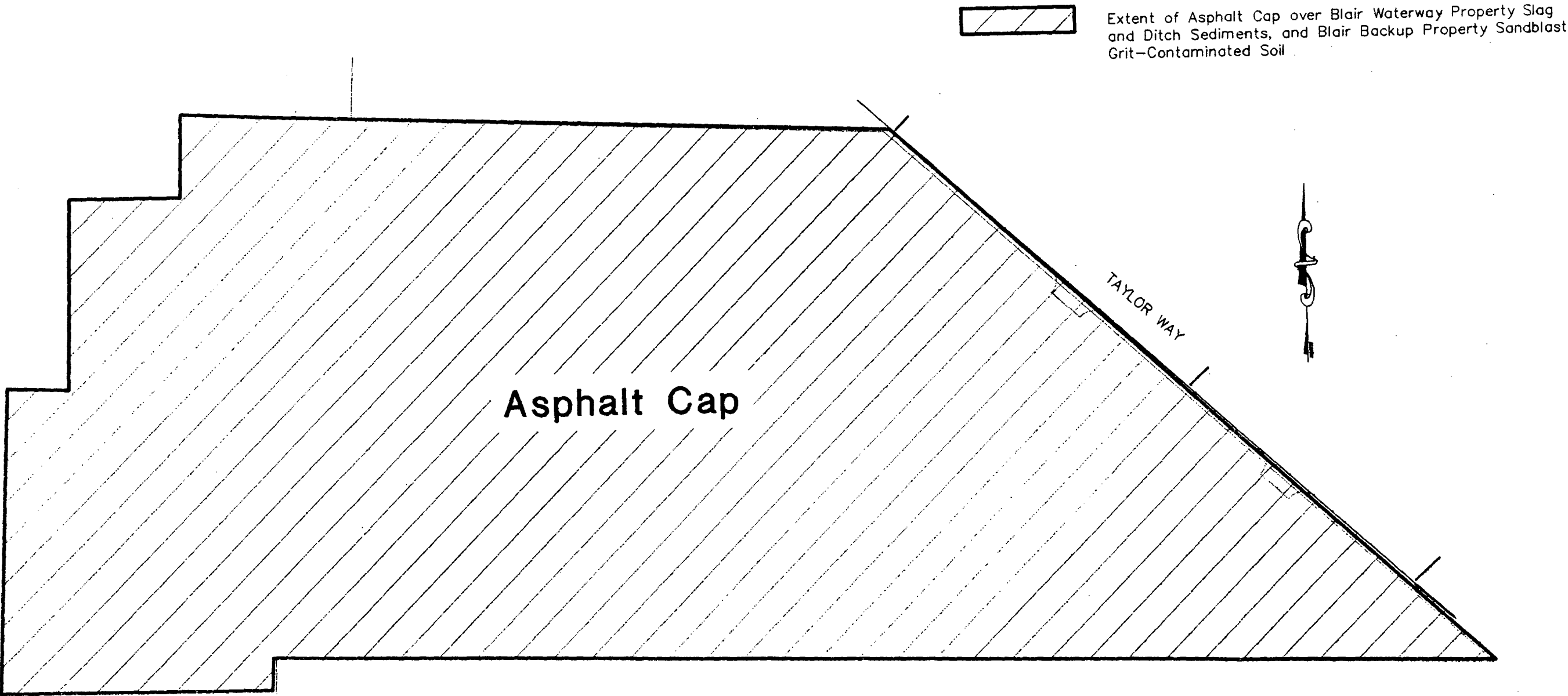
Combined Site Cleanup Option (Consolidate Slag at Blair Backup Property)	
Blair Waterway Property	\$870,000
Excavate slag and contaminated sediments, transport to Blair Backup property, fill Lincoln Avenue Ditch.	
Blair Backup Property	\$1,899,720
Consolidate Blair Waterway material (Asarco Slag and ditch sediments) with OFA slag-, sandblast grit-, and PAH-contaminated material, construct 7-acre cap (Option B).	
Total Combined Site Cleanup Cost Estimate	\$2,769,720

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Plan Showing Extent of Asphalt Cap for Combined Blair Properties Cleanup

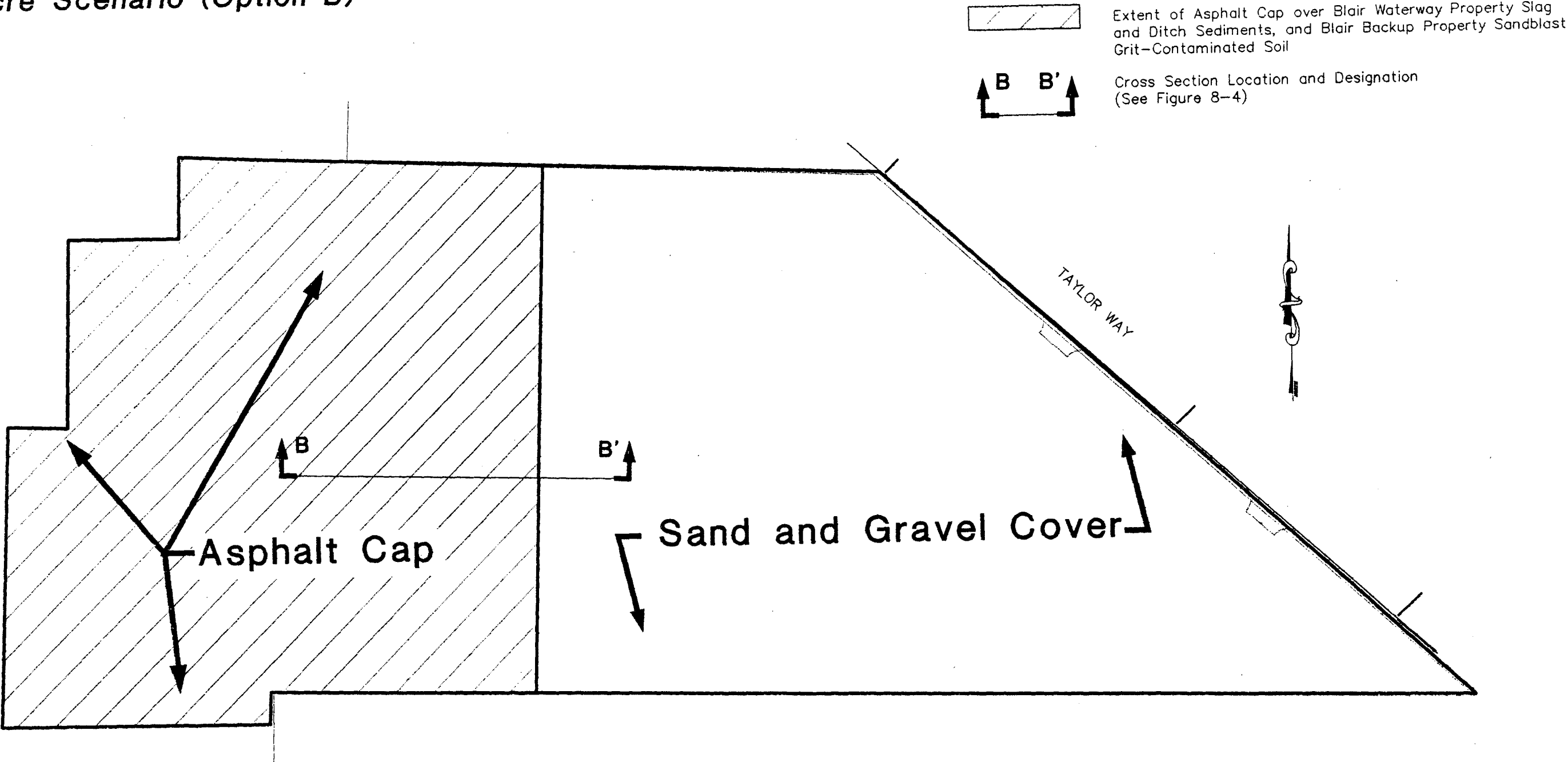
Blair Backup Property, Eastern Arm, OFA/Pennwalt Area

17-Acre Scenario (Option A)



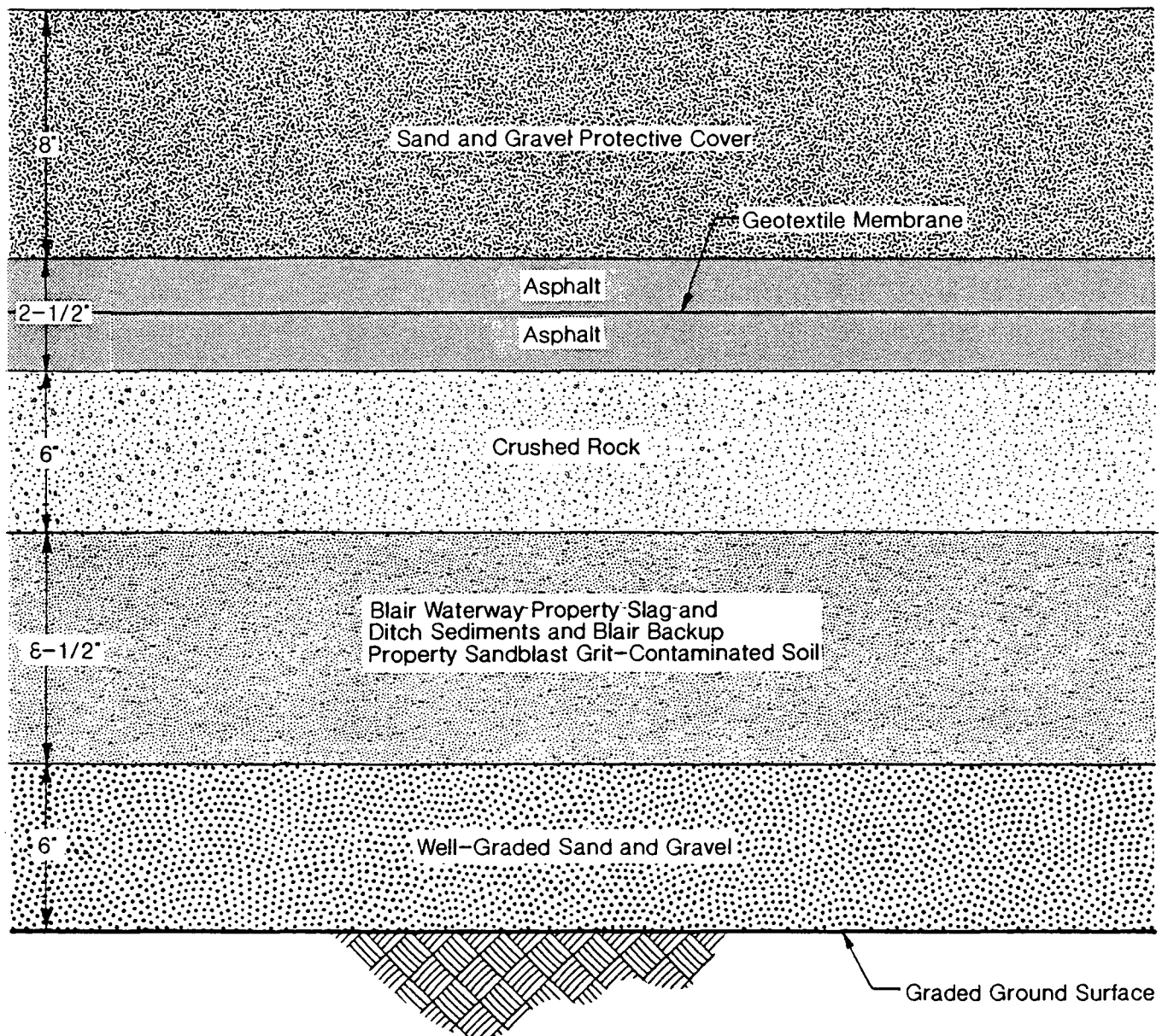
Plan Showing Extent of Asphalt Cap for Combined Blair Properties Cleanup

Blair Backup Property, Eastern Arm, OFA/Pennwalt Area
7-Acre Scenario (Option B)



Cross Section of Cap

Combined Blair Waterway and Blair Backup Properties
17- Acre Scenario (Option A)



Not to Scale

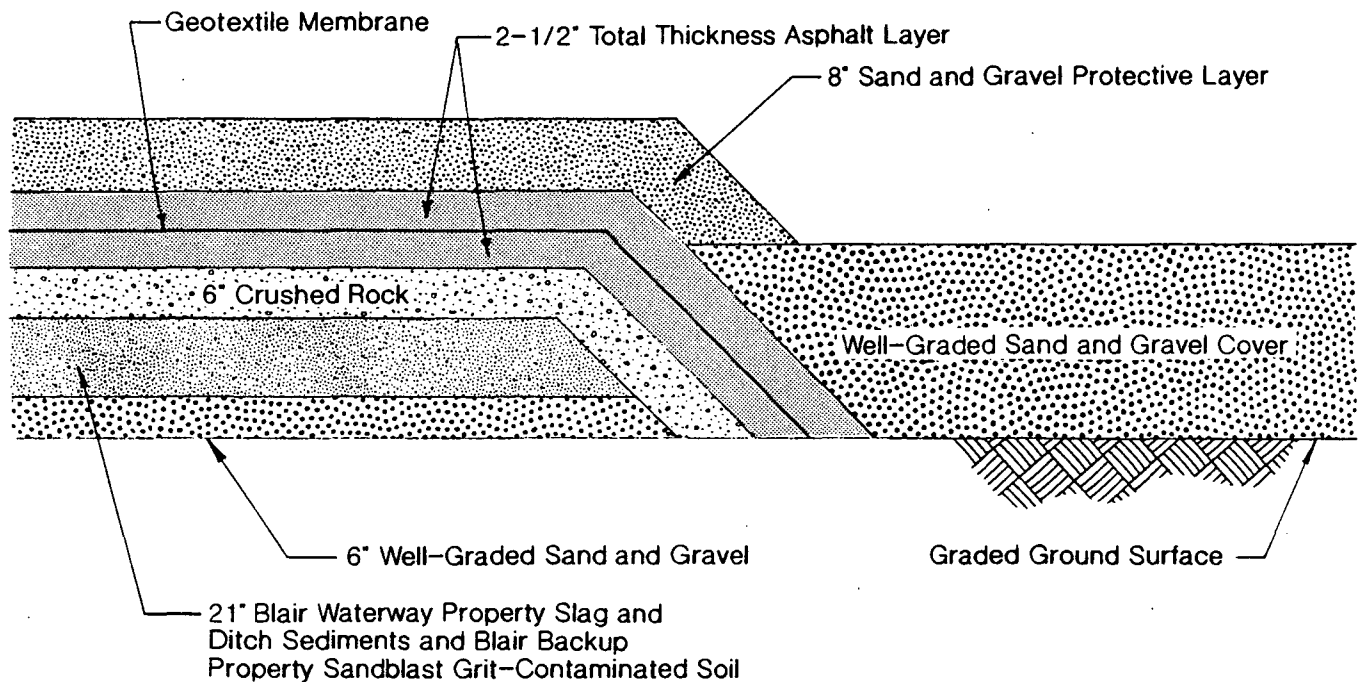


HARTCROWSER

J-2350-20 7/92

Figure 8-2

Cross Section B-B' of Cap **Combined Blair Waterway and Blair Backup Properties** **7-Acre Scenario (Option B)**



Not to Scale

REFERENCES

EPA, 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, U.S. CERCLA, U.S. Environmental Protection Agency, OSWER Directive 9355.3-01, October, 1988.

Hart Crowser, 1992a. Final Investigation Report, Blair Backup Property, Port of Tacoma, Washington, prepared for the Port of Tacoma, dated January 29, 1992, J-2350-07.

Landau, 1992. Analysis of Alternatives, Blair Waterway Property, Port of Tacoma, Tacoma, Washington, dated August 14, 1992 (Amended November 18, 1992).

Tetra Tech, 1989. Commencement Bay Nearshore/Tideflats Remedial Investigation, prepared for Washington State Department of Ecology and U.S. Environmental Protection Agency.

Tacoma, Port of, 1990. Memorandum of Agreement (MOA), Among the Puyallup Tribe of Indians, the Port of Tacoma, the Washington Department of Ecology, and the U.S. Environmental Protection Agency Regarding Implementation of the August 27, 1988 Puyallup Land Settlement Agreement, March 8, 1990.

REFERENC.lst

APPENDIX A
VINYL CHLORIDE IN NORTH SITE AREA GROUNDWATER

APPENDIX A VINYL CHLORIDE IN NORTH SITE AREA GROUNDWATER

Introduction

This appendix presents the results of additional groundwater sampling conducted in the North Site Area in February 1992. The additional sampling was conducted to verify our assessment that vinyl chloride concentrations detected in the groundwater in this area are decreasing with time. As presented in the Blair Backup Property Final Investigation Report (Hart Crowser, 1992), data collected during three sampling events in 1990 indicated vinyl chloride in the groundwater; however, the data also showed generally lower concentrations with each sampling event. Assuming this degradation, it was believed unlikely that any future site use risks would exist. If this was the case, no further action with regard to the groundwater in this area should be needed.

This report summarizes the previous data collection and analysis of groundwater in the North Site Area and then presents the scope of this 1992 investigation. Next, we discuss the results of the sampling and a discussion of the vinyl chloride trend analyses. We then present a re-evaluation of the potential future lifetime cancer risk. These analyses form the basis for our conclusion that no further action with regard to vinyl chloride in the North Site Area is needed.

Background

Vinyl chloride was detected in four North Site Area Shallow Aquifer groundwater wells (HC-7S, HC-8S, HC-9S, and HC-21S) at concentrations ranging from 5 to 86 $\mu\text{g/L}$ during three sampling events conducted in January, October, and December of 1990 (Hart Crowser, 1992). An apparent decrease in vinyl chloride concentrations with time was observed in the 1990 data. Figure A-1 shows the well locations and Table A-1 presents the vinyl chloride concentrations measured in the 1990 samples.

To confirm the apparent decreasing trend in the 1990 measured vinyl chloride concentrations, we proposed to resample the four North Site Area monitoring wells. The scope of this additional sampling was outlined in the Final Supplemental Site Assessment Work Plan Addendum dated February 28, 1992, and is summarized below.

Scope of Work

Four shallow wells (HC-7S, HC-8S, HC-9S, and HC-21S) located in the North Site Area were resampled in February of 1992. Groundwater samples collected from these wells (plus one duplicate and trip blank) were submitted to Laucks Testing Laboratories, Inc., for analysis of volatile chlorinated organic compounds using EPA Method 8010. Groundwater pH, temperature, specific conductivity, and dissolved oxygen content were measured in the field.

We also measured water levels in 12 shallow wells located in the northern portion of the Blair Backup property to evaluate groundwater flow directions. Previous water level data collected in this area indicated a groundwater divide in the area of the vinyl chloride-contaminated groundwater. Water level measurements taken in February 1990 and January 1991 indicate flow eastward north of the divide and flow southwestward south of the divide. In September 1990 (the dry season), all the groundwater in this area appeared to be moving to the southwest toward the North Site Area wetland.

1992 Groundwater Sampling Results

The results of the chlorinated volatile organics analyses were compared to the MTCA Method B marine surface water cleanup levels. The North Site Area shallow groundwater quality was compared to marine surface water standards because the Shallow Aquifer ultimately discharges into the Hylebos Waterway and the groundwater in this area is not considered suitable for potential future water supply uses (Hart Crowser, 1992). The cleanup level for vinyl chloride based on human consumption of marine aquatic organisms is 3 $\mu\text{g/L}$. Table A-2 presents a summary of the 1992 sampling results. The data validation report and laboratory certificates of analysis are presented in Attachment A-2. This attachment is presented in Volume II.

Vinyl chloride and trans-1,2-dichloroethene (DCE) were the only chlorinated volatile compounds detected in the four North Site Area shallow monitoring wells (Table A-2). Vinyl chloride concentrations ranged from not detected (HC-8S) to 12 $\mu\text{g/L}$ (HC-9S), with an average concentration of 6 $\mu\text{g/L}$. Trans-1,2-DCE was detected in three of the four wells at estimated concentrations ranging from 0.22 to 0.85 $\mu\text{g/L}$. However, the reported trans-1,2-DCE detections were estimated concentrations below the practical quantitation limit of 1 $\mu\text{g/L}$.

The vinyl chloride concentrations measured in three of the four wells slightly exceeded the MTCA Method B surface water cleanup level of 3 $\mu\text{g/L}$. None of the

detected trans-1,2-DCE concentrations exceeded the MTCA Method B marine surface water cleanup level of 4,850 $\mu\text{g/L}$.

Evaluation and Discussion of Results

Potential Source of Vinyl Chloride

No known sources of chlorinated solvents exist in the North Site Area; however, several potential historical sources were identified by Hart Crowser (see Section 5.4.2 in the Blair Backup Property Final Investigation Report), including a former septic tank area located on the adjacent Reichhold property. Groundwater flow directions are generally from the septic tank area toward the North Site Area. The septic tank system has not been in use for many years and was recently excavated and removed (CH2M Hill, 1991).

The occurrence of vinyl chloride in the environment is generally the result of degradation of higher molecular weight chlorinated solvents including tetrachloroethylene (PCE) and trichloroethylene (TCE). The absence of these constituents in North Site Area groundwater suggests that the source of vinyl chloride has been eliminated and only vinyl chloride residual remains. The vinyl chloride concentration data further suggests this residual is decreasing with time as discussed below.

Vinyl Chloride Levels Decreasing with Time

Vinyl chloride concentrations measured in February of 1992 were up to an order of magnitude lower than levels observed during the previous sampling events (Table A-1). The highest concentration observed during the February 1992 sampling event was 12 $\mu\text{g/L}$ (HC-9S), compared to 85 $\mu\text{g/L}$ (HC-7S) encountered in January 1990.

The rate of concentration decrease indicates the average North Site Area Shallow Aquifer vinyl chloride concentrations should decrease to below the MTCA Method B marine surface water cleanup level of 3 $\mu\text{g/L}$ by the end of 1993. This is based on the statistical and graphical evaluation of the data presented on Figure A-2.

Figure A-2 presents a logarithmic plot of the upper 95% confidence limit of the mean for each sampling event versus time. A linear regression analysis of these data indicates a decreasing trend that can be used to determine the rate of concentration decrease. The slope of the line indicates that the half-life (the time required to decrease halfway between its initial and final concentrations) of vinyl chloride in the North Site Area Shallow Aquifer is approximately 8 months (± 3

months). At this rate, the average concentration of vinyl chloride in the North Site Area groundwater should be below the MTCA Method B surface water cleanup levels by the end of 1993.

Concentration trends for each individual well are presented on Figure A-3. These also show an apparent decrease in concentrations with time in essentially all the wells.

Volatilization is likely to be the primary attenuation (concentration reducing) mechanism for the vinyl chloride in the unconfined Shallow Aquifer of the North Site Area. Because the rate of volatilization of vinyl chloride is extremely difficult to accurately model, empirical or field studies are often the best way to evaluate the rate of contaminant volatilization from groundwater systems. Thus for the North Site Area Shallow Aquifer, the rate of vinyl chloride attenuation, evaluated by monitoring groundwater vinyl chloride concentrations over time was deemed appropriate.

Potential for Impact

The potential for vinyl chloride to impact either the wetlands and the Reichhold S Ditch or the Hylebos Waterway is highly unlikely. Because the groundwater in the Shallow Aquifer in the North Site Area flows toward and ultimately discharges to these water bodies, the potential for environmental impact was evaluated. The potential for impact is considered insignificant based on the following rationale:

- ▶ Organics will likely rapidly degrade upon reaching the wetland. The concentrations of organics observed in the 1990 data were considered too low to be of concern to the biological integrity of the wetland ecosystem (Pentec, 1991).
- ▶ Migration of vinyl chloride to the Reichhold S Ditch is also unlikely given the low levels present in the North Site Area groundwater and the rapid rate of volatilization of vinyl chloride in surface water bodies. If vinyl chloride was discharged to the ditch, it would be rapidly volatilized and ultimately photooxidized. Vinyl chloride has not been detected in Reichhold S Ditch surface water samples.
- ▶ It is also unlikely that the vinyl chloride will ever impact the Hylebos Waterway aquatic life. A portion of the North Site Area shallow groundwater flows toward Taylor Way during only a portion of the year (wet season). Groundwater flowing toward Taylor Way is likely to discharge to the backfill

around the Taylor Way storm drain or mix with groundwater beneath the Atochem facility. We have estimated that groundwaters discharged to the Taylor Way backfill drain could be diluted by as much as 10-fold. The average vinyl chloride concentration in groundwater is currently at a concentration of 6 $\mu\text{g/L}$. It would only take a two-fold dilution to reduce the concentrations to below the 3 $\mu\text{g/L}$ MTCA marine surface water cleanup level.

If groundwater was not intercepted by the backfill around the drain and traveled beneath the Atochem facility, it would likely be diluted by dispersion and discharged via volatilization to below the MTCA cleanup level before discharge to the Hylebos Waterway. The limited and seasonal nature of the Shallow Aquifer in this area suggests it is highly unlikely for any input of vinyl chloride to the Hylebos Waterway via this pathway.

Analysis of Risk to Future On-Site Workers

The Blair Backup Property Final Investigation Report (Hart Crowser, 1992) concluded that the principal potential for impact from the vinyl chloride was a human health risk for future site workers via volatilization from groundwater and inhalation of vapors collected in indoor air space. Based on the 1990 data, the potential lifetime excess cancer risk from inhalation of vinyl chloride vapors was estimated to be 10^{-5} for the average case and 2×10^{-5} for the reasonable maximum exposure (RME) case.

We re-evaluated the future human health risks associated with commercial and industrial use of the North Site Area using the 1992 data. The only change in our analysis from the previous risk assessment was in the upper 95% concentration level of vinyl chloride. We used 11 $\mu\text{g/L}$ based on the currently measured vinyl chloride levels versus 50 $\mu\text{g/L}$ used for the previous risk assessment. Attachment A-1 presents the supporting assumptions and factors used for the risk evaluation.

The potential risk due to inhalation of vapors emitted from groundwater and collected in a confined space under the RME scenario is 3×10^{-6} as shown in Table A-3. This risk value is within the MTCA target risk level of 1×10^{-5} .

Conclusions

Based on the findings of this work, we do not believe remediation, institutional controls, or further monitoring activities are necessary to address the presence of vinyl chloride in North Site Area shallow groundwater. Vinyl chloride

concentrations in the North Site Area Shallow Aquifer appear to be decreasing rapidly and will not likely significantly impact human health and the environment.

References

CH2M Hill, 1991. Corrective Measures Phase 1 Update 1990, prepared for Reichhold Chemicals Inc., March 1991.

Hart Crowser, 1992. Final Investigation Report, Blair Backup Property, Port of Tacoma, Washington, prepared for the Port of Tacoma, dated January 29, 1992, J2350-07.

Pentec Environmental, 1992. Re: Potential Impacts of Existing and Future Activities on the Existing Wetland, North Site Area, Blair Backup Property, Port of Tacoma, letter to Port of Tacoma, dated January 3, 1992.

Table A-1 – Historical Summary of Vinyl Chloride Concentrations in
North Site Area Shallow Groundwater

Sampling Event	Monitoring Well Locations			
	HC-7S	HC-8S	HC-9S	HC-21S
January 1990	85	10	NA	NA
October 1990	22	24	63	64
December 1990	44	5.5 (a)	12	27
February 1992	4.8 (a)	1.8 U	12	7.9

Notes:

Vinyl chloride concentrations are in $\mu\text{g/L}$.

(a) Average of two replicate samples.

U Not detected at indicated detection limit.

NA Not available.

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Table A-2 – Summary of February 1992 North Site Area Groundwater Quality Data

Sample ID	HC-7S	HC-7D	HC-8S	HC-9S	HC-21S	Trip Blank
Collection Date	2/21/92	2/21/92	2/21/92	2/21/92	2/21/92	2/21/92
Volatile Organic Compounds						
in µg/L (ppb)						
Vinyl chloride	4.8	4.8	1.8 U	12	7.9	1.8 U
trans-1,2-Dichloroethene	0.75 J	0.85 J	0.22 J	1.0 U	0.62 J	1.0 U
Chloroform	0.50 U	0.50 U	0.50 U	0.50 U	0.73 UB	0.91 B
Field Parameters						
pH	7.4	NA	7.0	6.4	7.1	NA
Temperature in °C	10	NA	8.0	9.5	8.8	NA
Specific Conductivity in µmhos	780	NA	320	360	1670	NA
Dissolved Oxygen in ppm	2	NA	3	2	NA	NA

Notes:

U Not detected at indicated detection limit.

B Analyte detected in associated method blank.

J Estimated value below detection limit.

NA Not available.

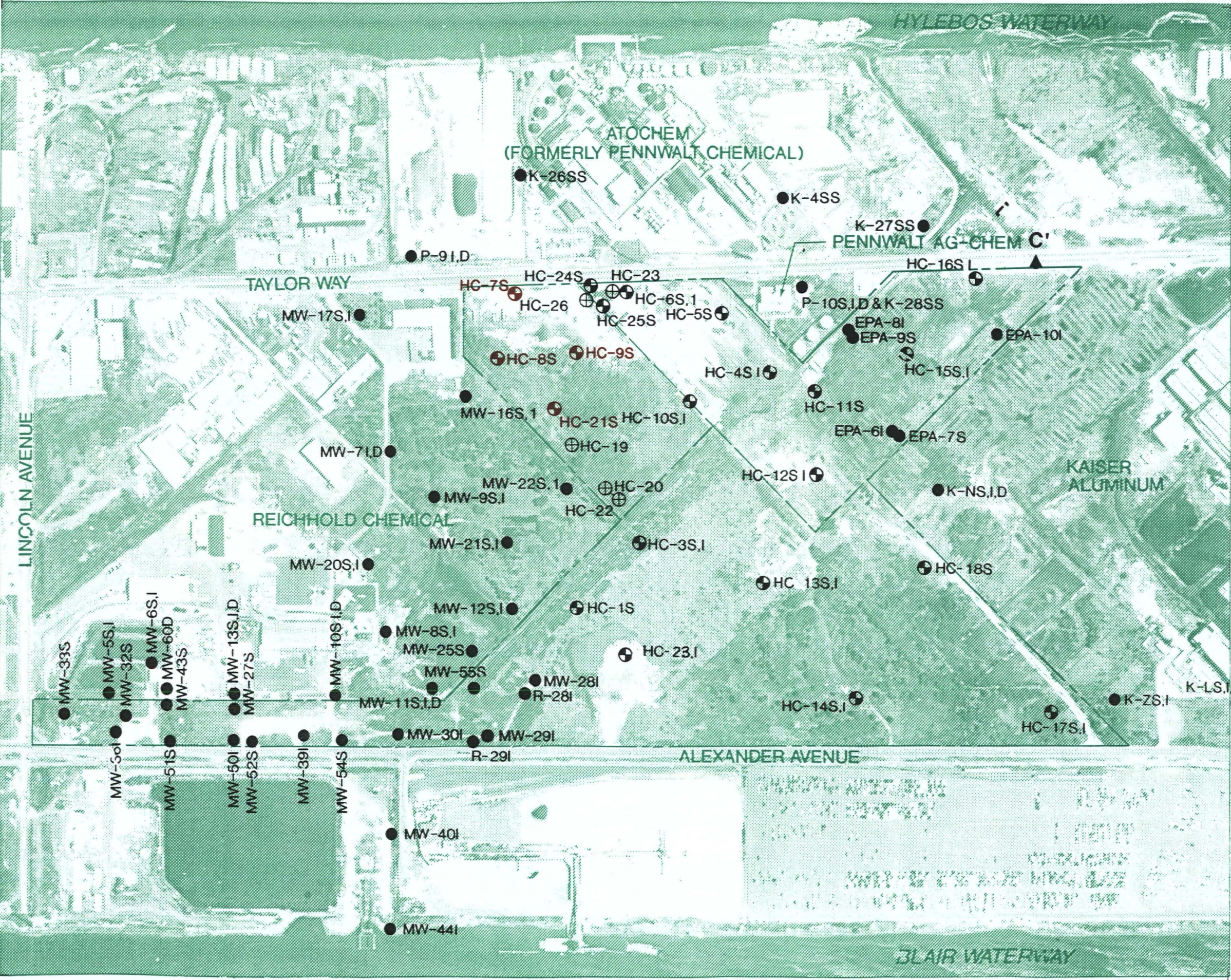
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Table A-3 – Estimated Doses and Potential Risks to Future On-Site Workers from Inhalation of Chemicals Volatilized from On-Site Groundwater: North Site Area

Chemical (a)	Groundwater Concentration in $\mu\text{g/L}$ (c)		Total Mass in Shallow Aquifer in kg (d)		Estimated Indoor Air Concentration in mg/m^3 (e)		RME Chronic Daily Intake in mg/kg-day (f)	Inhalation Slope Factor in $(\text{mg/kg-day})^{-1}$	Upper-bound RME Lifetime Excess Cancer Risk
	Average	95% CL	Average	RME	Average	RME			
Potentially Carcinogenic Chemicals									
Vinyl chloride	6.4	11	1.0	1.7	3.4E-04	6.0E-04	1.2E-05	0.295 (g)	3.0E-06
								TOTAL RISK	3.0E-06
Non-carcinogenic Chemicals									
(b)								HAZARD INDEX	0E+00

- (a) Air concentrations were estimated only for chemicals with inhalation toxicity criteria.
 (b) No chemicals of potential concern with non-carcinogenic inhalation toxicity factors were detected in this area.
 (c) Average and upper 95% concentrations were calculated from the February 1992 sampling event.
 (d) Parameters used to determine the mass of vinyl chloride in the North Site Shallow Aquifer are presented in Table A-1.
 (e) Parameters used to estimate indoor air concentrations are presented in Table A-2.
 (f) Chronic daily intake values were calculated using the factors presented in Table A-2.
 (g) Calculated using an inhalation unit risk (IRIS, 1991) assuming an inhalation rate of $20\text{m}^3/\text{day}$ by a 70 kg individual.

North Site Area Groundwater Sampling Location Plan



Monitoring Well Location and Number

- HC-8S North Site Area Wells Sampled for Vinyl Chloride
- HC-1 Hart Crowser
- EPA-9 EPA
- MW-16 CH2M Hill
- P-10 Pennwalt
- K-N Kaiser
- K-27 Kennedy Jenks

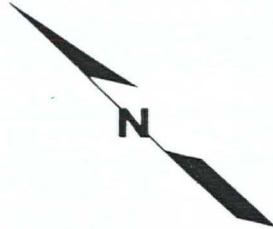
Aquifer Tapped by Well

- S Shallow
- I Intermediate
- D Deep

Note: Wells are clustered installations.

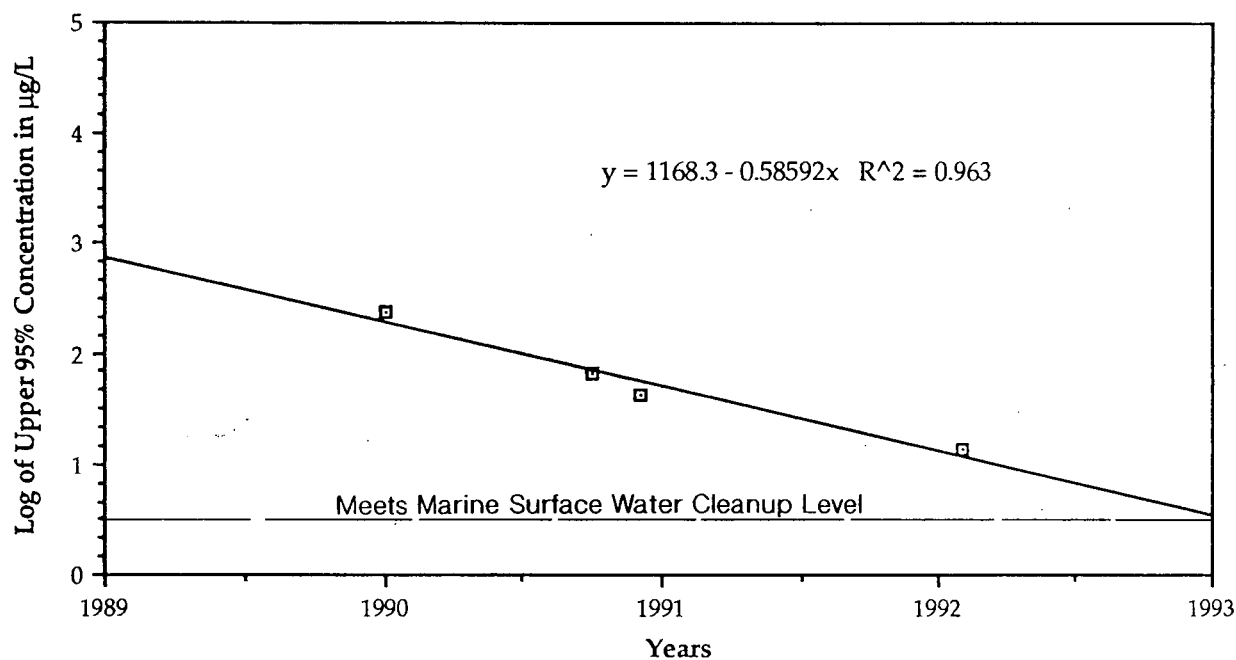
HC-26 Hart Crowser Boring

Note: Base map prepared from aerial photograph of the Port of Tacoma dated June 1, 1989.

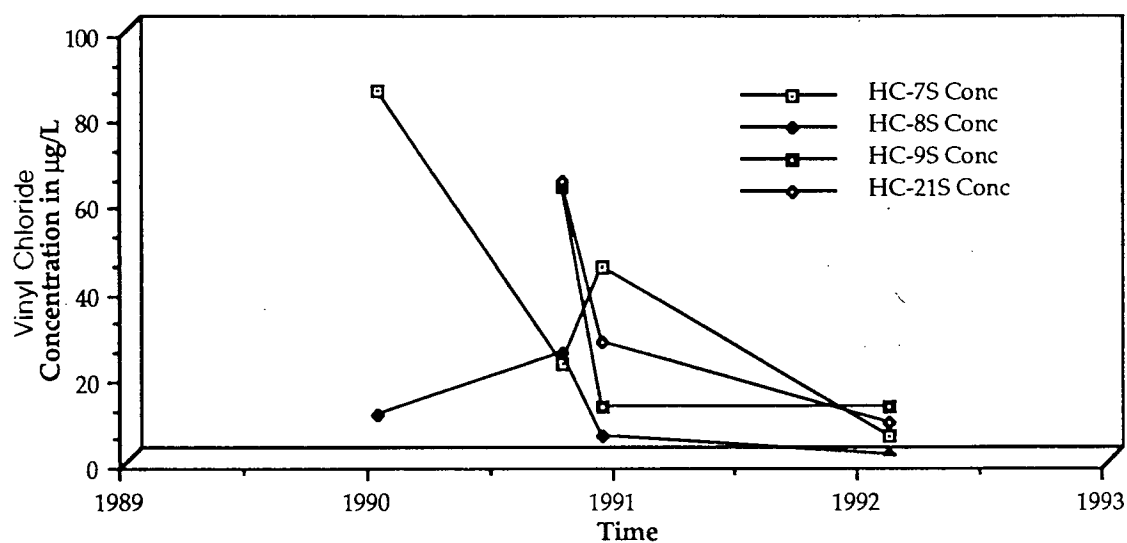


0 400 800
Approximate Scale in Feet

Distribution of Vinyl Chloride Concentrations in North Site Area Shallow Groundwater over Time



Vinyl Chloride Concentrations in North Site Area Shallow Monitoring Wells over Time



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Figure A-3

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**ATTACHMENT A-1
RISK ASSESSMENT FACTORS
AND ASSUMPTIONS**

Table A-1-1 - Estimation of Quantities of Vinyl Chloride in the North Site Area Shallow Aquifer

Chemical	Cw in mg/L		Koc in L/kg	Kd in L/kg	Mw in mg		Ms in mg		Mtotal in kg	
	Average	95% CL			Average	95% CL	Average	95% CL	Average	95% CL
Vinyl chloride	0.0064	0.011	8	0.246	5.8E+05	9.9E+05	3.9E+05	6.7E+05	1.0	1.7

Input Parameters for Source Term Calculation

Parameter	Symbol	North Site Area
Site Area	A	49,300 m2
Saturated thickness	b	5.2 m
Total porosity	pT	0.35
Bulk density	BD	1.5 gm/cm3
Soil organic carbon	foc	0.03

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**Table A-1-2 – Values and Assumptions Used to Estimate Vinyl Chloride
Indoor Air Concentrations and Chronic Daily Intake**

Indoor Air Model

Symbol	Parameter	Value	Source
	building dimensions	50 m x 50 m x 3 m	assumed
A	area of infiltration	2300 m ²	floor area minus area of 1-m perimeter wall
V	indoor air volume	7500 m ³	calculated
ACH	air exchange rate	0.2 (hr ⁻¹)	conservative assumption
F	infiltration fraction	100%	conservative assumption

RME Exposure Factors: Inhalation Scenario

RME Exposure Factors Carcinogens	
Intake rate	79 m ³ /day
Exposure frequency	36%
Exposure duration	40 years
Body weight	70 kg
Lifetime	75 years

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J-2350-20

APPENDIX B
SURFACE WATER AND SEDIMENT QUALITY
IN THE REICHHOLD S DITCH

APPENDIX B

SURFACE WATER AND SEDIMENT QUALITY IN THE REICHHOLD S DITCH

Introduction

The purpose of this appendix is to present the results of our assessment of surface water and sediment quality in the Reichhold S Ditch. In the Blair Backup Property Final Investigation Report (Hart Crowser, 1992), we recommended additional sampling of the Reichhold S Ditch to verify previous surface water and sediment quality data and to determine if any remedial actions would be needed.

We have divided this appendix into seven sections. As part of this introductory section, we present brief summaries of the physical characteristics of the ditch, findings of previous sampling conducted on the Reichhold S Ditch, and objectives of our field investigation. Following the introduction, we describe the scope of the field program. The next four sections discuss the results of our sediment quality, surface water quality, surface water flow, and sediment transport evaluations. We conclude this appendix with a summary of our findings.

Laboratory certificates of analysis and the results of our data quality review are presented in Attachment B-1 (in Volume II). A map showing the Blair Backup site and the four major areas is presented on Figure B-1. Sampling locations in the Reichhold S Ditch are shown on Figure B-2.

Physical Characteristics

The Reichhold S Ditch is the most prominent drainage feature on the Blair Backup property. The ditch begins in the northeastern corner of the General/Fill Area and runs parallel to the south Reichhold fenceline as shown on Figure B-2. The bottom of the ditch is over 8 feet below ground surface and is predominantly covered with vegetation, including grass and cattails. The upper 6 inches of sediment in the ditch is typically composed of silty sand or silt with abundant organic material (primarily decaying plant remains). Iron-staining was generally observed in the upper few inches of the sediment column. The ditch water exits the site through an underground culvert in the southeast corner of the property and ultimately discharges to the Lincoln Avenue Ditch, west of Alexander Avenue.

A small ditch draining the central portion of the North Site Area discharges into the head of the Reichhold S Ditch. Baseflow in the Reichhold S Ditch is derived from this ditch and from groundwater discharges from the Shallow Aquifer in the General/Fill Area of the Blair Backup property and from shallow subsurface

discharges from the wetland in the North Site Area. Water levels at most locations in the ditch are generally only a few inches deep.

Water levels and flows in the ditch are tidally influenced. At high tide, the flow direction in the ditch reverses and the water level rises significantly. The rise in water levels in the ditch is most pronounced near the discharge point of the ditch where the water level rises 3 to 4 feet. Only a slight rise in water levels (several inches) has been observed near the head of the ditch.

Background Information

Sediment and surface water in the Reichhold S Ditch were sampled by Reichhold Chemical Inc. in March of 1988 as part of their off-site drainageways investigation (CH2M Hill, 1989). Elevated concentrations of trace metals were observed in the Reichhold S Ditch sediment samples. Arsenic, copper, lead, molybdenum, and zinc concentrations were reported to be above naturally occurring averages in at least one of the six sediment samples collected by Reichhold. However, arsenic was the only metal that exceeded MTCA Method A industrial soil or marine sediment cleanup criteria. Arsenic concentrations in the samples collected by Reichhold ranged from 27 to 400 mg/kg with the highest concentrations occurring in the central portion of the ditch. Reichhold was not able to identify the source of these metals.

Elevated concentrations of several trace metals were also detected in the six surface water samples collected from the Reichhold S Ditch in March of 1988. Average total arsenic (7.8 $\mu\text{g/L}$), copper (23 $\mu\text{g/L}$), nickel (93 $\mu\text{g/L}$), and zinc (163 $\mu\text{g/L}$) concentrations exceeded local background reference levels (as defined in Table 23 of the Blair Backup Property Final Investigation Report) and MTCA Method B marine surface water cleanup levels for these metals. However, the arsenic data are questionable as the arsenic concentrations measured in split samples (2 to 5 $\mu\text{g/L}$) by another laboratory (Battelle) were all within the range of local background reference levels. None of the average metal concentrations exceed MTCA Method B freshwater cleanup levels (assuming a hardness of 415 mg/L as calcium carbonate).

Potential Sources of Metals to Ditch

The source of these elevated metal concentrations may have been from groundwater or surface water discharges to the Reichhold S Ditch. There were three potential metals sources identified. These include the former discharge of surface waters from the Pennwalt Ag-Chem Ditch, runoff from areas containing sandblast grit in the north-central North Site Area, and groundwater from the General/Fill Area.

Two of these potential sources no longer exist: the Pennwalt Ag-Chem Ditch drainage has been blocked and filled so it no longer discharges to the Reichhold S Ditch, and the sandblast grit has been removed. The third potential source, groundwater discharge from the General/Fill Area, appears to be due to natural phenomenon and therefore, cannot be reasonably controlled. Each of these potential sources is discussed below in reference to the applicable sediment and surface water quality data.

Objectives of the Field Investigation

The primary objectives for conducting additional sampling of the Reichhold S Ditch are to verify the existing data and to determine whether remedial actions are necessary. Specific objectives include:

- ▶ Obtaining representative sediment quality data for comparison to regulatory criteria;
- ▶ Providing data to assess the transport of sediment via suspension in surface water;
- ▶ Collecting representative surface water quality data for comparison to regulatory criteria; and
- ▶ Evaluating the potential impact of surface water discharges from the Reichhold S Ditch on the Blair Waterway.

The scope of this additional sampling was outlined in the Final Supplemental Site Assessment Work Plan Addendum dated February 28, 1992, and is summarized below.

Field Program

Our field work was accomplished in February and March of 1992. The samples were collected during the typical wet season; however, sampling was conducted during a period of low precipitation.

Sediments

We collected four discrete sediment samples (SED-1 through SED-4) at locations shown on Figure B-2. Discrete samples were collected by driving 3-inch-diameter stainless-steel Shelby tubes to depths of approximately 1 foot. The upper one-half

(0.5) foot of sediment within each Shelby tube was placed in 16-ounce sample jars and submitted for pH and total metals analysis (including arsenic, chromium, copper, lead, nickel, and zinc).

In order to assess the potential impact of suspended sediment transport in ditch surface water, we also collected and analyzed three composite near-surface (0 to 0.1 foot) sediment samples (CSED-1 through CSED-3) for pH and total metals. Each composite sample was composed of sediment collected at the four discrete sample locations spatially distributed over the length of the ditch. Samples composited over the length of the ditch were deemed representative of the suspended sediment load that would discharge to the culvert at the mouth of the ditch.

Surface Water

Surface water in the Reichhold S Ditch was sampled at two locations shown on Figure B-2. Sample SW-RD-1 was collected near the origin of the ditch and reflects the chemistry of surface water entering the ditch from the North Site Area and the northwestern portion of the OFA/Pennwalt Area. Sample SW-RD-2 collected near the culvert exiting the site (adjacent to Alexander Avenue) reflects the water quality of all input between the small North Site Area ditch and the mouth of the ditch that primarily includes Shallow Aquifer groundwater from the General/Fill Area and shallow subsurface discharges from the wetland in the North Site Area.

Because the ditch is tidally influenced and flow direction reverses at high tide, surface water was sampled at low tide (low stage) to reduce the influence of mixing with off-site (downstream) waters. The two surface water samples were analyzed for total and dissolved metals (including arsenic, chromium, copper, lead, nickel, and zinc), total dissolved and suspended solids, and hardness. In addition, three surface water samples (including one replicate sample) were collected at intermediate and high tide stages and analyzed for total suspended solids to evaluate sediment transport from the Reichhold S Ditch. Surface water pH, temperature, and conductivity were measured in the field at the time of sampling.

Surface water flow data were collected concurrently with water sampling activities so that metal loading to the Blair Waterway could be estimated. A flume was used to measure the rate at which surface water in the small North Site Area ditch discharged into the Reichhold S Ditch. Flow velocities at the discharge point (culvert) of the Reichhold S Ditch were measured using a flow meter. Flow velocities and discharge rates were obtained at low, intermediate, and high tide stages to determine the range in flows and the amount of time that flow from the site occurs. In order to assess the relative impact of metal loading from the

Reichhold S Ditch, we also measured the surface water discharge rate in the Lincoln Avenue Ditch and compared it to the volume of surface water discharge from the Reichhold S Ditch.

Sediment Quality Results

Sediment quality results were screened relative to Model Toxics Control Act (MTCA) industrial soil cleanup levels (WAC 173-340-745(1)) and Puget Sound Marine Sediment Quality Criteria (Chapter 173-204 WAC) in an effort to identify chemicals of concern and assess potential environmental or human health impacts. Currently, there are no state or federal freshwater sediment criteria. Table B-1 summarizes the sediment quality data collected to date and the regulatory criteria used for comparison.

Summary of Analytical Results

Arsenic and lead are the only metals that exceed MTCA Method A industrial soil cleanup levels or state marine sediment quality criteria in ditch sediment samples collected as part of this investigation (Table B-1). None of the 0.1-foot composite samples exceeded the criteria, and only one of the 0- to 0.5-foot samples exceeded the criteria for lead and arsenic. However, the average arsenic concentration (94 mg/kg) and lead concentration (290 mg/kg) collected within the upper 0.5-foot of the sediment column are below MTCA industrial soil criteria. The average lead concentration is also below marine sediment criteria, while the arsenic level slightly exceeds the marine sediment standards.

The elevated arsenic levels in the ditch sediment may be related to the former discharge of surface water from the Pennwalt Ag-Chem Ditch area. Elevated concentrations of some metals, including arsenic, were found in the Pennwalt Ag-Chem Ditch and in the OFA/Pennwalt Area soils around the ditch (Hart Crowser, 1992). However, surface water flow from this area no longer occurs so the source of arsenic to the ditch has probably been eliminated. The near-surface samples (0 to 0.1 foot) support this hypothesis as they show an apparent decrease in arsenic concentrations with time by comparing the average near-surface (0 to 0.1 foot) sediment concentration of 52 mg/kg to the average discrete (0 to 0.5 foot) sediment arsenic concentration of 94 mg/kg.

Sandblast waste in the North Site Area is currently being removed and is unlikely to impact Reichhold S Ditch sediment quality in the future. We anticipate that the concentration of the lead and other metals will decrease with time as relatively clean sediments are deposited in the ditch.

Only sample SED-2 slightly exceeded the arsenic criteria. This sample was obtained from the same general location of the 1988 Reichhold sampling (SDOF CS04 and SDOF CS02), which had an indicated elevated arsenic concentration. However, the current data indicate the arsenic concentrations in Reichhold S Ditch sediment have significantly decreased. Sediment samples collected by Reichhold in this area encountered arsenic levels of 370 and 400 mg/kg in the upper 0.5 foot of sediment, whereas the 1992 sample (SED-2) contained only 240 mg/kg of arsenic.

Surface Water Quality Results

Surface water quality results were screened relative to MTCA Method B marine and freshwater cleanup levels (WAC 173-340-730) and residential stormwater runoff average concentrations as determined in Metro's Toxicants in Urban Runoff Study (Metro, 1982) in an effort to identify chemicals of potential concern and assess where remedial actions may be required at the site (Table B-2).

The Washington State freshwater cleanup levels are the most appropriate screening criteria for Reichhold S Ditch surface water since the water is primarily fresh (low salinity relative to seawater), and the aquatic environment consists primarily of freshwater habitat. In addition, the MTCA point of compliance for surface waters is the point of discharge of the hazardous material into the surface water body (WAC 173-340-730 (6)). The low stage Total Dissolved Solids (TDS) data are similar to the Shallow Aquifer groundwater levels (see Table B-2), indicating the ditch water is predominantly freshwater.

Because the Reichhold S Ditch ultimately discharges to the Blair Waterway (via the Lincoln Avenue Ditch), it is also useful to compare the surface water quality data to marine criteria. MTCA Method B freshwater and marine criteria are all based on Clean Water Act aquatic life chronic criteria. Surface water quality for protection of human health is not of concern since the metals identified in the Reichhold S Ditch do not present a fish consumption health risk in Commencement Bay based on the risk assessment conducted as part of the Commencement Bay Nearshore/Tideflats RI/FS (Tetra Tech, 1989).

Summary of Analytical Results

None of the metal concentrations detected in the two Reichhold S Ditch surface water samples exceed MTCA Method B freshwater cleanup levels (Table B-2). Total copper (3 and 8 $\mu\text{g/L}$) and nickel (41 and 58 $\mu\text{g/L}$) slightly exceed the MTCA Method B marine cleanup levels of 2.9 for copper and 8.3 $\mu\text{g/L}$ for nickel. However, the total (3 $\mu\text{g/L}$) and dissolved copper (< 2 $\mu\text{g/L}$) concentrations in the

sample collected near the ditch discharge point (SW-RD-2) are extremely low, will be below MTCA marine cleanup levels before the surface water reaches the Blair Waterway due to mixing and attenuation, and are much lower than the average residential stormwater runoff concentration of 20 $\mu\text{g/L}$. Arsenic and zinc concentrations do not exceed MTCA Method B marine cleanup levels.

Metals concentrations in the two surface water samples collected during the February 1992 sampling event were generally lower than the levels observed in the samples collected by Reichhold in 1988. A direct comparison between the data sets cannot be made because Reichhold collected their data at various times throughout the tidal cycle and we collected our samples at low tide.

Discussion of Nickel Occurrence

The elevated nickel concentrations in the Reichhold S Ditch surface water appear to be primarily related to the discharge of groundwater from the General/Fill Area Shallow Aquifer. The average dissolved nickel concentration in shallow wells located adjacent to the ditch (HC-1S, HC-2S, HC-3S, and HC-13S) is 275 $\mu\text{g/L}$. Surface water discharge from the small ditch draining the North Site Area also contains elevated nickel (total nickel concentration of 58 $\mu\text{g/L}$ measured in sample SW-RD-1), which may act as a more secondary source.

The presence of elevated nickel concentrations in General/Fill Area shallow groundwater appears to be the result of natural geochemical reactions occurring in the area. Much of the General/Fill Area consists of seasonally flooded vegetated areas. Surface water in this area was generally acidic, with measured pH levels at 14 monitoring locations ranging from 3.8 to 6.8.

Low pH levels in surface water are common in such areas due to the abundance of organic materials (which release organic acids and produce carbon dioxide, which is converted to carbonic acid) and changing redox conditions. In many of the areas containing shallow surface water, we observed the presence of iron precipitates. As iron precipitates, it changes oxidation states ($\text{Fe}+2$ to $\text{Fe}+3$) and releases hydrogen ions, which lowers the pH of the surface water. Oxidation of sulfide, which is likely to be present in the dredge fill and former tide flat soil materials which comprise the General/Fill Area Shallow Aquifer system, also results in lowering surface water pH. Nickel and other trace metals are generally much more mobile in acidic environments. In addition, the mobility of nickel is enhanced via complexation with humic acids produced by organic matter.

The elevated nickel in the General/Fill Area shallow groundwater does not appear to be related to major anthropogenic sources. The General/Fill Area has never been developed and metals concentrations in General/Fill Area subsurface soils are within regional background levels. Small quantities of sandblast grit waste have been observed south of well HC-13S. However, it seems unlikely that the sandblast grit is the primary source of nickel to General/Fill Area shallow groundwater given the limited leachability and volume of the sandblast grit waste. Shallow Aquifer wells located in the sandblast grit area in the North Site Area contained an average nickel concentration of only 11 $\mu\text{g/L}$, compared to 275 $\mu\text{g/L}$ in the Shallow Aquifer wells located in the General/Fill Area. A surface soil sample collected from road construction debris located in the vicinity of well HC-2S contained a nickel concentration of 200 mg/kg. However, the occurrence of elevated nickel concentrations in the construction debris appears to be highly localized, since four other subsurface soil samples collected from this same area did not contain elevated metal concentrations.

It is not likely that surface water discharge of nickel from the ditch will significantly impact the Blair Waterway marine environment. The flux of nickel to the Lincoln Avenue Ditch and subsequently to the Blair Waterway appears to be minor, given the relatively low flow rate in the ditch and the flow reversals that occur during high tide (see discussion below). Also, much of the General/Fill Area Shallow Aquifer goes dry during the dry season, thus eliminating the major input of nickel to the ditch. The Blair Waterway is not designated as a problem area by the CB/NT Record of Decision (ROD). In addition, nickel concentrations measured in Lincoln Avenue Ditch sediments are generally within the range of area background reference concentrations.

Surface Water Flow Characteristics

Flow velocities and discharge volumes for the small North Site Ditch, the Reichhold S Ditch, and the Lincoln Avenue Ditch are presented in Table B-3. Measurements were collected over a two-day period in which there was a fairly large tidal exchange (0.1 to 11.3 feet MLLW). The flow characteristics were evaluated to assess the impact of metals loading to the Lincoln Avenue Ditch and to understand the dilution that would occur in the Lincoln Avenue Ditch prior to discharge to the Blair Waterway. A summary of the flow characteristics is given in the following sections.

The Reichhold S Ditch is fed by groundwater discharge, North Site wetland discharge, and surface water drainage from the North Site Ditch. A gain of approximately 70 to 80 gallons per minute (gpm) was observed between the small North Site Ditch at the head of the Reichhold S Ditch and the culvert outlet (See

Table B-3). We can account for only a small fraction of this gain by groundwater discharge. Groundwater discharge is estimated to be approximately 1 to 2 gpm based on data collected in the Blair Backup Property Final Investigation Report (Hart Crowser, 1992). No surface water inputs other than the measured North Site Ditch were observed.

We suspect that most of the water entering the Reichhold S Ditch as baseflow is derived from the wetland area located in the southern portion of the North Site Area. During the wet season, the southern half of the North Site Area floods and is covered with up to several feet of water. Much of this water appears to drain into the head of the Reichhold S Ditch via shallow near-surface flow. Another possible source of water is the release of bank storage, which is water that is temporarily stored in the sides of the ditch during high tide conditions.

Tidal Influence on Reichhold S Ditch Surface Water Flow

Surface water in the Reichhold S Ditch predominantly flows toward the Lincoln Avenue Ditch and ultimately the Blair Waterway. At high tide, flow in the Reichhold S Ditch reverses and the water level rises as much as 4 feet near the discharge point of the ditch depending on the magnitude of the high tide. As the tide recedes, surface water flow in the ditch begins to discharge from the site. This reversal happens within minutes and water levels in the Reichhold S Ditch drop very rapidly (inches per minute). Discharge from the site continues until the water level in the Lincoln Ditch rises above the Reichhold S Ditch outfall. We estimated that the Reichhold S Ditch was discharging from the Blair Backup property roughly 75 percent of the time during our field measurement program. However, this is likely to be highly dependent on the magnitude and duration of the tidal cycle as well as the magnitude of other surface water discharges into the Lincoln Avenue Ditch, west of Alexander Avenue.

Flow Velocities

Flow velocities in the Reichhold S Ditch do not vary significantly between low and high stages (see Table B-3). Maximum flow velocities in the ditch probably occur during storm events at a low tide stage. Flow velocities measured near the Reichhold S Ditch discharge point during the 1992 wet season averaged 0.32 feet per second (ft/sec). At this low flow rate, very little or no sediment can be suspended and transported based on grain size critical velocities. Very little turbidity was observed in the Reichhold S Ditch and measured Total Suspended Solids (TSS) concentrations were extremely low (14 to 44 mg/L). The only solids we observed being transported in the ditch surface water were floating organic material

(grass, leaves, etc.) and fibrous iron flocculants. The dominance of fine-grain materials (including fine sand, silt, and clay) in the Reichhold S Ditch surface sediment supports the premise that surface water flow velocities in the ditch are low.

The rate of surface water discharge from the Reichhold S Ditch ranged from 0 (reverse flow) to 1,300 gpm. Discharge rates drop rapidly from high stage to low stage such that most of the discharge from the ditch occurs during low stage conditions. The average discharge rate from the site sources is roughly 70 to 90 gpm.

Reichhold S Ditch and Lincoln Avenue Ditch Flows Compared

In the Lincoln Avenue Ditch, low stage flow velocities are approximately twice that of the Reichhold S Ditch. A flow rate of approximately 0.71 ft/sec and a discharge of 170 gpm was measured on March 9, 1992. These data indicate that discharges from the Reichhold S Ditch, during at least certain times of the year, could account for approximately 50 percent of the total discharge to the Blair Waterway from the Lincoln Avenue Ditch. Thus, surface water exiting the Reichhold S Ditch is at a minimum diluted with an equal volume of water in the Lincoln Avenue Ditch before discharging into the Blair Waterway. At this dilution rate, only nickel (at a level of approximately 20 $\mu\text{g/L}$) will still exceed the marine surface water cleanup level of 8.3 $\mu\text{g/L}$. Tidal mixing and soil absorption will only further decrease any metals concentrations in surface water eventually reaching the Blair Waterway.

Sediment Transport

The transport of sediments containing elevated metal concentrations by Reichhold S Ditch surface water is minimal. As discussed previously, very little sediment can be suspended and transported in the Reichhold S Ditch due to its low flow velocity. Very little turbidity was observed in the Reichhold S Ditch and measured total suspended solids concentrations were extremely low (less than 50 mg/L). Although higher flow velocities may occur in the ditch during storm events, it does not appear that significant transport of sediment occurs given the high silt and clay content of the surface sediment.

Based on the maximum total suspended solids value of 44 mg/L and the average surface sediment arsenic concentration of 52 mg/kg, we calculated that less than 3 $\mu\text{g/L}$ of arsenic could potentially be transported by Reichhold S Ditch surface water (not including dissolved arsenic). This is consistent with the total arsenic concentration (less than 5 $\mu\text{g/L}$) measured in the surface water sample collected near the ditch discharge point.

Conclusions

Based on the sampling and analysis results, we do not believe remediation or further monitoring activities are necessary to address surface water and sediment quality in the Reichhold S Ditch. The major findings include:

- ▶ **Sediment.** Arsenic and lead are the only metals that exceeded MTCA Method A industrial soil cleanup levels or Puget Sound marine sediment quality criteria in discrete ditch sediment samples collected as part of this investigation. However, average lead concentration (290 mg/kg) in the four discrete samples is well below both screening criteria and the average arsenic concentration is below MTCA industrial soil criteria but only slightly exceeds the marine sediment standards. In addition, a comparison with historical data indicates arsenic concentrations in the sediment are decreasing suggesting that the source(s) of arsenic to the ditch has been reduced or eliminated. Removal of sandblast waste in the North Site Area should eliminate the primary source of lead to the ditch. In addition, the transport of sediments containing elevated metal concentrations is minimal due to its low flow velocity.
- ▶ **Surface Water.** None of the metal concentrations detected in the two Reichhold S Ditch surface water samples exceed MTCA Method B freshwater cleanup levels. Total copper concentrations slightly exceed the MTCA Method B marine cleanup levels of 2.9 $\mu\text{g/L}$. However, the total and dissolved copper concentrations measured near the ditch discharge point are extremely low ($<5 \mu\text{g/L}$), will be below MTCA marine cleanup levels before the surface water reaches the Blair Waterway due to mixing and attenuation, and are much lower than the average residential stormwater runoff concentration of 20 $\mu\text{g/L}$.

Nickel concentrations in ditch surface water exceed the MTCA marine cleanup level of 8.3 $\mu\text{g/L}$. However, the presence of elevated nickel concentrations in General/Fill Area shallow groundwater appears to be the result of natural geochemical reactions occurring in the area. It is not likely that surface water discharge of nickel from the Reichhold S Ditch will significantly impact the Blair Waterway marine environment given the relatively low flow rate in the ditch and the flow reversals that occur during high tide. Also, much of the General/Fill Area Shallow Aquifer goes dry during the dry season, thus eliminating the major input of nickel to the ditch.

References

CH2M Hill, 1989. Sediment and Surface Water Report: Off-site Drainageways; prepared for Reichhold Chemicals, Inc., Tacoma Facility, February 1989.

Hart Crowser, 1992. Final Investigation Report, Blair Backup Property, Port of Tacoma, Washington, prepared for Port of Tacoma, dated January 29, 1992, J-2350-07.

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Tetra Tech, 1989. Commencement Bay Nearshore/Tideflats Remedial Investigation, prepared for Washington State Department of Ecology and U.S. Environmental Protection Agency.

TPCHD, 1988. Tacoma-Pierce County Health Department. Drainage Map - Commencement Bay Nearshore/Tideflats Area; prepared for Washington State Department of Ecology, July 1, 1988.

Table B-1 – Summary of Reichhold S Ditch Sediment Quality Data

			Metals in mg/kg (ppm)						Other Parameters	
Sample ID	Collection Date	Depth in Feet	Arsenic	Chromium	Copper	Lead	Nickel	Zinc	Total Solids in Percent	pH
1992 Sampling Results										
SED-1	2/24/92	0.0 to 0.5	76	21	220	1,100	25	370	62.9	6.5
SED-2	2/24/92	0.0 to 0.5	240	10 U	71	50	47	190	19.7	5.9
SED-3	2/24/92	0.0 to 0.5	41	7	19	10 U	18	96	51.3	6.6
SED-4	2/24/92	0.0 to 0.5	20	16	30	10 U	20	67	62.5	6.8
CSED-1	2/24/92	0.0 to 0.1	3.4	9	41	14	16	64	40.9	6.5
CSED-2	2/24/92	0.0 to 0.1	65	3	34	13	14	77	37.1	6.6
CSED-3	2/24/92	0.0 to 0.1	88	4 U	28	14	17	110	35.3	6.8
1988 Sampling Results (d)										
SDOF CS06	March 1988	0.0 to 0.5	68.5	26.1	118	214	23.8	282	NA	NA
SDOF CS05	March 1988	0.0 to 0.5	23	9.8	35	19	10	61	NA	NA
SDOF CS04	March 1988	0.0 to 0.5	400	24	96	70	35	360	NA	NA
SDOF CS03	March 1988	0.0 to 0.5	370	16	62	30	27	180	NA	NA
SDOF CS02	March 1988	0.0 to 0.5	27	10	13	5.6	10	65	NA	NA
SDOF CS01	March 1988	0.0 to 0.5	69	14	33	16	20	180	NA	NA
SDOF CS061 Dup	March 1988	0.0 to 0.5	75	16	33	19	23	200	NA	NA
Regulatory Criteria Used for Screening Sediment Data										
MTCA Method A Industrial Soil Cleanup Levels (a)			200	500	---	1,000	---	---	---	---
Puget Sound Marine Sediment Quality Standards (b)			57	260	390	450	---	410	---	---
Puget Sound Marine Sediment Cleanup Screening Levels (c)			93	270	390	530	---	960	---	---

Notes:

U Not detected at indicated detection limit.

NA Not available.

- (a) Ecology, February 1991, MTCA Cleanup Levels (Chapter 173-340-745 WAC).
- (b) Ecology, April 1991, Sediment Management Standards, Table 1 Marine Sediment Quality Standards – Chemical Criteria (Chapter 173-204 WAC).
- (c) Ecology, April 1991, Sediment Management Standards, Table 2 Marine Sediment Impact Zones – Maximum Chemical Criteria (Chapter 173-204 WAC).
- (d) Samples collected as part of Reichhold Chemicals Offsite Drainageways Sediment and Surface Water Investigation (CH2M Hill, 1989).

Table B-2 - Summary of Reichhold S Ditch Surface Water Results

Sample ID:	SW-RD-1	SW-RD-2	SW-RD-2	SW-RD-2	SW-RD-3	MTCA Method B	Residential	MTCA Method B
Water Stage:	Low	Low	Intermediate	High	High	Freshwater	Stormwater Runoff	Marine Surface
Location:	Head	Discharge	Discharge	Discharge	Rep. of SW-RD-2	Cleanup	Average	Water Cleanup
Collection Date:	3/10/92	3/10/92	3/10/92	3/10/92	3/10/92	Levels (a,c)	Concentrations (b)	Levels (a,e)
Total Metals in µg/L								
Arsenic	9	5 U				190	13	36
Chromium	4	4				11 (d)	8	50 (d)
Copper	8	3				40	20	2.9
Lead	2	2				19	210	5.6
Nickel	58	41				530	12	8.3
Zinc	81	60				350	115	86
Dissolved Metals in µg/L								
Arsenic	9	5 U				---	---	---
Chromium	3	4				---	---	---
Copper	4	2 U				---	---	---
Lead	1 U	2				---	---	---
Nickel	56	41				---	---	---
Zinc	75	58				---	---	---
Other Parameters								
Hardness as CaCO ₃ in mg/L	340	490				---	---	---
Total Dissolved Solids in mg/L	970	1600	2200 J	11000 J	11000 J	---	---	---
Total Suspended Solids in mg/L	16	21	44	15	14	---	---	---
Temperature in °C	11	11				---	---	---
pH	6.7	6.7				---	---	---
Specific Conductivity in µMhos	1280	2200				---	---	---

Notes:

U Not detected at indicated detection limit.

J Estimated value.

(a) Ecology, February 1991, MTCA Cleanup Levels (Chapter (173-340-730 WAC).

(b) Samples were collected in Bellevue, Washington, as part of Metro's Toxicants in Urban Runoff Study (December 1982).

(c) Based on Clean Water Act freshwater aquatic life chronic toxicity criterion (Hardness = 415 mg/L as CaCO₃).

(d) For hexavalent chromium only, cleanup level for trivalent chromium is 210 µg/L.

(e) Based on Clean Water Act marine aquatic life chronic toxicity criterion.

2350T-B2.wk1

**Table B-3 – Summary of Reichhold S and Lincoln Avenue Ditch
Surface Water Discharge Rates**

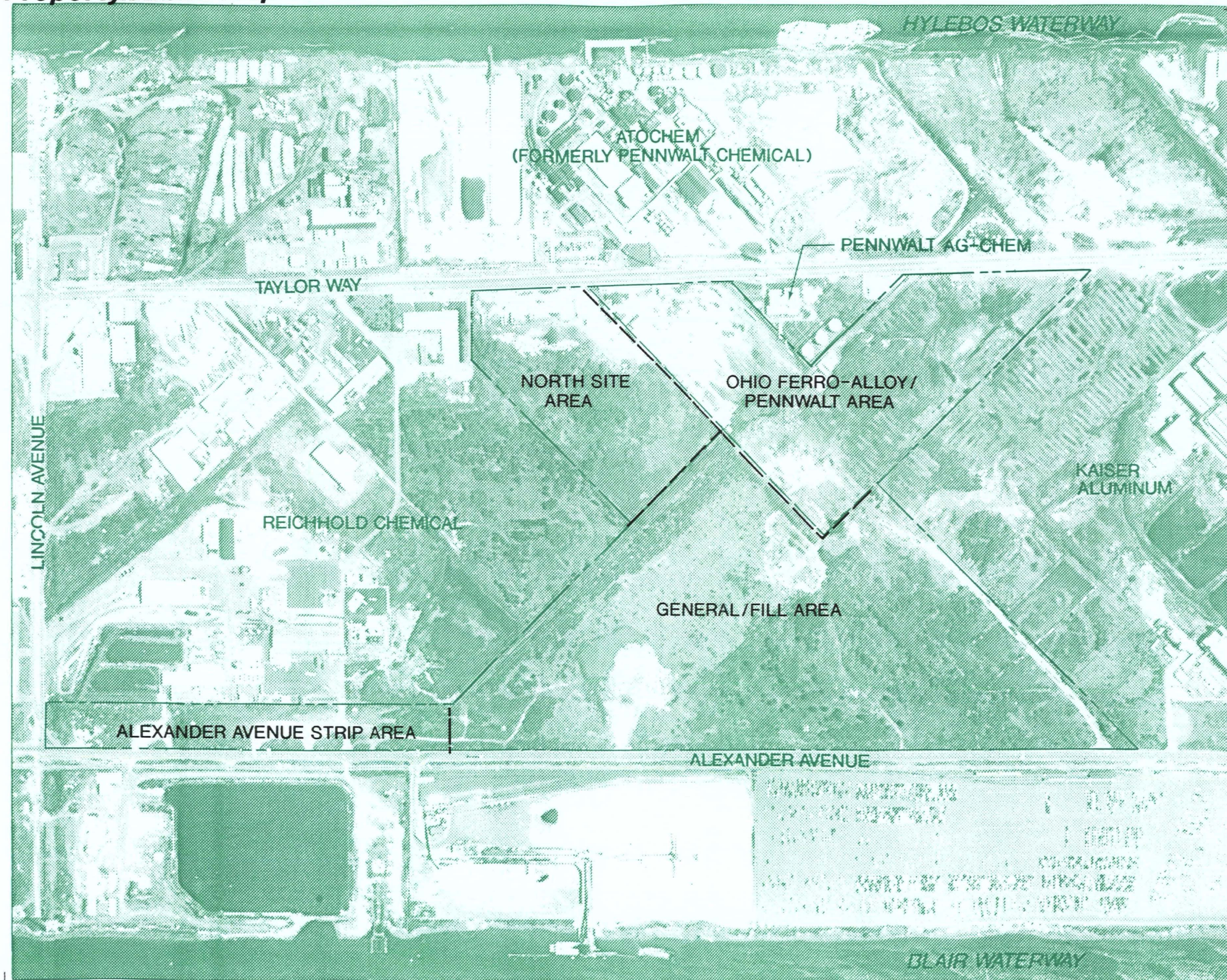
Ditch	Date of Measurement	Time	Flow Velocity in ft/sec	Discharge Rate in gpm
North Site Ditch				
Low Stage (a)	3/9/92	15:50	—	3
Low Stage (b)	3/10/92	13:15	—	2
Reichhold S Ditch (Culvert)				
Low Stage (a)	3/9/92	14:15	0.32	91
Low Stage (b)	3/10/92	14:30	0.26	74
Intermediate Stage	3/10/92	09:45	0.34	140
High Stage (c)	3/10/92	09:00	0.35	1,300
Lincoln Avenue Ditch				
Low Stage	3/9/92	13:10	0.71	170

Notes:

- (a) Low tide of +0.3 MLLW (Mean Low Low Water) at 14:16.
- (b) Low tide of +0.1 MLLW at 15:06.
- (c) High tide of +11.3 MLLW at 07:50.

2350T-B3.wk1

Property Areas Map



Note: Base map prepared from aerial photograph of the Port of Tacoma dated June 1, 1989.

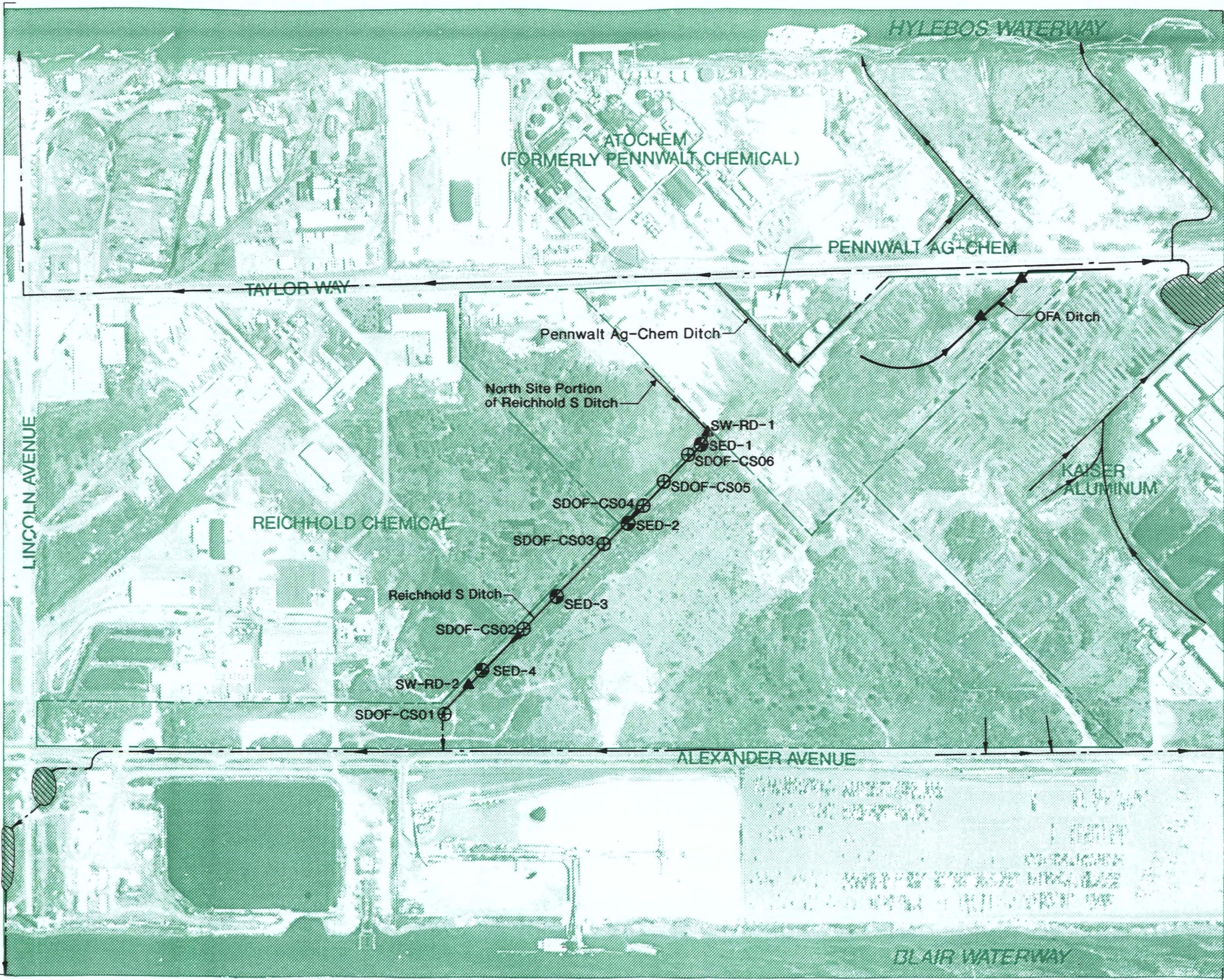


0 400 800
Approximate Scale in Feet



HARTCROWSER
J-2350-20 6/92
Figure B-1

Surface Water and Sediment Sampling Location Plan Reichhold S Ditch



- ⊕ SED-1 Drainage Ditch Sediment Sampling Location
- ▲ SW-RD-1 Surface Water Sampling Location
- ⊕ SDOF-CS06 Surface Water and Ditch Sediment Sampling Location by Reichhold (CH₂M Hill, 1989)
- Closed Surface Water Drainage
- Open Surface Water Drainage

Drainage data obtained from the Commencement Bay-Nearshore/Tideflats Area Drainage Map (TPCHD, 1988) with modifications made based on January 1991 observations.

Note: Base map prepared from aerial photograph of the Port of Tacoma dated June 1, 1989.



0 400 800
Approximate Scale in Feet

APPENDIX C
SURFACE WATER QUALITY IN THE OFA DITCH

APPENDIX C SURFACE WATER QUALITY IN THE OFA DITCH

This appendix presents the results of additional surface water quality monitoring conducted in the Ohio Ferro-Alloy (OFA) Ditch in March and April of 1992. The sampling was conducted to better understand the variability observed in the metals data previously collected from the OFA Ditch. Our hypotheses were that occasional elevated metals concentrations were related to particulates in the surface water and blockage of the ditch that pooled site surface waters allowing greater contact time and area with on-site slag-containing soils. In early 1992 the OFA Ditch was reconstructed to allow better drainage. The March and April 1992 samplings were conducted to allow a more representative assessment of the quality of off-site surface water discharges.

This appendix is presented in four sections which include:

- ▶ *Introduction*, which presents a brief description of the physical characteristics of the ditch and results of previous surface water sampling;
- ▶ *Objectives and Scope of the Spring 1992 Field Program*, which discusses the sampling and analysis work contracted;
- ▶ *Surface Water Quality Results*, which present the analytical data, regulatory criteria used to evaluate the data and discusses our interpretation of the results; and
- ▶ *Conclusions*, which summarize the findings relative to the potential for on-site or off-site impacts to the environment.

A map showing the Blair Backup property and the four major areas is presented on Figure C-1. Sampling locations in the OFA Ditch are shown on Figure C-2. Results of our data quality review and laboratory certificates of analysis are presented in Attachment C-1 (presented in Volume II).

Introduction

Physical Characteristics of the OFA Ditch

The OFA Ditch is a shallow man-made feature located in the eastern arm of the Blair Backup property (hereafter referred to as the OFA/Pennwalt Area). The ditch

currently begins approximately 100 feet south of the Pennwalt Ag-Chem tank (Atochem) area and runs to the southeastern corner of the OFA/Pennwalt Area where it discharges to a steel culvert which flows under Taylor Way to the Kaiser Ditch as shown on Figure C-2.

Because the ditch tends to become blocked up with wood debris, it has been reconstructed at slightly different locations several times over the past few years. The most recent March 1992 reconstruction unblocked the ditch at the culvert and extended the ditch westward to better drain the central portion of the OFA/Pennwalt Area. The western portion of the ditch consists of a fairly well-defined channel with a width of 4 to 5 feet and a depth of 2 to 3 feet. The eastern half of the ditch is poorly defined and is not as wide or deep as the western portion of the ditch. There is only minor vegetation in the eastern portion of the ditch.

The OFA Ditch primarily drains surface water although it also received minor amounts of groundwater during much of the year. The ditch generally does not contain flowing water during the summer and fall or during extended dry periods in the winter and spring months. Based on observations during years of on-site field monitoring, we estimate that discharge from the OFA Ditch occurs during only 25 to 40 percent of the year (assuming the ditch does not become blocked).

The OFA Ditch is constructed in a slag-containing fill material which is present over most of the OFA/Pennwalt Area. The fill material contains a mixture of soil, wood chips, rock, wood and concrete debris, and slag. Most of the slag is from a former smelting operation operated by OFA, with small amounts of Asarco slag presumably imported to the site incidentally during former log yard operations. Fill material adjacent to the eastern ditch area contains a fairly high percentage of slag (mostly Asarco slag) relative to the rest of the OFA/Pennwalt Area. Sediment in the bottom of the ditch is typically composed of silt containing abundant organic matter and minor amounts of gravel, including slag.

Previous Surface Water Sampling Data

There were four previous surface water samplings of the OFA Ditch. The Washington State Department of Ecology (Ecology) previously sampled surface water in the vicinity of the ditch in 1983 and 1984 as part of an area-wide log yard study (Ecology, 1985). Two additional samplings were conducted in 1990 and 1991 by Hart Crowser during the primary field investigation phase of the Blair Backup Property transfer project (Hart Crowser, 1992). The results indicated a substantial

variability in metals concentrations (particularly arsenic, copper, and zinc) as shown by a summary of the historical chemical data presented in Table C-1.

The Ecology surface water sampling in the OFA/Pennwalt Area was conducted as part of a log yard study to evaluate the impact of Asarco slag, commonly used by log sorting yards as ballast material, on surface water quality. The OFA/Pennwalt Area was sampled because log sorting yards, including the Cascade Timber Yard Number 2, occupied the OFA/Pennwalt Area periodically from 1974 to the mid-1980s. Two surface water samples for trace metal analysis were collected in the eastern portion of the OFA/Pennwalt Area in December 1983 and June 1984. We were unable to determine the specific location of the sampling in a thorough search of Ecology files which included interviews with the Ecology study authors.

As Table C-1 shows, elevated concentrations of total (unfiltered) antimony, arsenic, copper, lead, nickel, and zinc were detected in at least one of the two samples. The highest concentrations were measured in 1984. The 1984 sample was also extremely turbid with a Total Suspended Solids (TSS) concentration of 7,800 mg/L. For reference, the 1983 Ecology sample and more recent samples collected by Hart Crowser exhibited TSS levels ranging from 11 to 87 mg/L, including samples collected under comparable or higher flow conditions. The extremely high suspended solid content in the 1984 sample significantly biases the results toward higher metal concentrations.

The surface water samples collected from the OFA Ditch in 1990 and 1991 by Hart Crowser indicated significantly lower metal concentrations than the Ecology data. Arsenic and copper were the only metals which were determined to be of potential concern. Total arsenic concentrations ranged between 24 and 230 $\mu\text{g/L}$ with the highest arsenic concentration occurring in a sample collected during a period when the ditch was blocked. Total copper concentrations ranged from 61 to 240 $\mu\text{g/L}$. We believe that the higher concentrations were due to the "stagnant" water sample collected at a time when the ditch was blocked. The blockage caused increased contact area and time with the slag-containing fill materials.

Objectives and Scope of the Spring 1992 Sampling

The objective of the Spring 1992 sampling was to better assess the potential for water quality impacts to the environment. Specifically, we desired an accurate representation of metals concentrations in on-site surface water and in off-site discharges to assist us in remedial alternative evaluation. Our work included sampling the surface water in the OFA Ditch at two locations for metals and general indicator parameters. Concurrently, we measured flow rates in the ditch to allow

comparison with the previous Ecology data and to assess off-site loading of metals. The specific scope of this additional sampling was outlined in the Final Supplemental Site Assessment Work Plan Addendum dated February 28, 1992, and is summarized in the following paragraphs.

Surface water in the OFA Ditch was sampled at two locations shown on Figure C-2. Samples were collected in March of 1992 (denoted by the -392- designation) during a period of relatively little rainfall. In April of 1992, a second round of samples were collected (denoted by the -492- designation) during a rainy period. Samples OFA-SW-392-2 and OFA-SW-492-2 were collected near the origin of the ditch and likely reflect the water quality of surface water and shallow groundwater present in the northern and central portions of the OFA Area. Samples OFA-SW-392-1 and OFA-SW-492-1 were collected near the culvert exiting the site (adjacent to Taylor Way) and reflect the composite water quality of groundwater and surface water discharges from most of the OFA/Pennwalt Area.

The four surface water samples were analyzed for total and dissolved metals (including arsenic, cadmium, chromium, copper, iron, lead, manganese, nickel, and zinc), total dissolved solids, total suspended solids, and hardness. Surface water, pH, temperature, and conductivity were measured in the field. Field measurements of dissolved oxygen content of the water were obtained during the April sampling event.

Surface water flow data were collected using a variety of techniques including a flow meter, a bucket, and stopwatch, and measuring the velocity of floating objects. A flow rate of between 30 and 60 gallons per minute (gpm) was measured at the culvert during the Spring 1992 sampling events. This flow rate is roughly equivalent to the average daily precipitation (0.2 inch/day) during the wet season (December through March) falling on the eastern portion of the OFA/Pennwalt Area. Thus these flows are probably average for the site during the wet season. The measured discharge rate is very similar to the rate of 45 gpm measured by Ecology following a rainfall event in June of 1984.

Surface Water Quality Results

The results of the Spring 1992 surface water quality testing are presented in Table C-2. These data were compared to MTCA Method B freshwater and marine surface water cleanup levels (WAC 173-340-730) in an effort to identify chemicals of potential concern to aquatic life. MTCA Method B freshwater and marine criteria are based on federal Clean Water Act (40 CFR 136) aquatic life chronic criteria.

For general reference purposes, residential stormwater runoff quality data (METRO, 1982) are also presented in Table C-2.

MTCA freshwater cleanup levels are the most appropriate screening criteria for OFA Ditch surface water since the water is primarily fresh (low salinity relative to seawater) and the aquatic environment would consist primarily of freshwater organisms if any life existed in the ditch. Under MTCA, surface water cleanup criteria are applied at the point where the contaminant discharges to the surface water body which, in this case, is in the OFA Ditch. The numerical fresh water criteria for selected metals is based on the hardness of the water as given by an equation relating the cleanup level to an exponential of the hardness value. We used the average hardness data from the March and April 1992 sampling events to determine the cleanup level for screening purposes. The hardness reflects the amount of bicarbonate in the water which in turn determines the species of the metal and thus its toxicity.

Because the OFA Ditch ultimately discharges to the Hylebos Waterway (via the Kaiser Ditch), we also compared the surface water quality data to marine aquatic life criteria.

Summary of Analytical Results

Total and dissolved metals data are presented in Table C-2 along with the general indicator parameters including hardness. The total metals data represent the concentration of metals associated with both particulate (suspended solids) and dissolved phases. Dissolved metal concentrations represent the sample without solids greater than 0.45 microns in size as these samples were filtered in the field using a 0.45 micron filter.

Arsenic, copper, and lead are the only metals detected in the five samples (including one replicate sample) collected during this field investigation which exceed either MTCA freshwater or marine surface water cleanup levels (Table C-2). Total and dissolved arsenic concentrations, which ranged from 82 to 160 $\mu\text{g/L}$ and 33 to 83 $\mu\text{g/L}$, respectively, do not exceed the MTCA freshwater cleanup level of 190 $\mu\text{g/L}$. Total lead concentrations (7 to 10 $\mu\text{g/L}$) slightly exceed the MTCA freshwater cleanup level of 8 $\mu\text{g/L}$ in three of the five samples; however, dissolved lead concentrations (<1 to 5 $\mu\text{g/L}$) are all below the MTCA freshwater criteria. Total copper concentrations (20 to 51 $\mu\text{g/L}$) exceed the MTCA freshwater cleanup level of 22 $\mu\text{g/L}$ in four of the five samples collected; however, dissolved copper concentrations (1 to 32 $\mu\text{g/L}$) exceed the MTCA freshwater criteria in only one sample.

Comparison to Historical Data

In general, metal concentrations observed in surface water samples collected as part of this investigation are within or below the range of concentrations detected in the previously collected samples. For example, the average total copper concentration in the most recent samples (42 $\mu\text{g/L}$) is almost three times lower than the historical average of 115 $\mu\text{g/L}$ (not including the 1984 EPA sample). The recent data represent the current OFA Ditch surface water quality and better reflect the quality of surface water runoff and discharges from the site. This is because the OFA Ditch has been reconstructed, unblocked, and extended to drain a much larger portion of the OFA/Pennwalt Area. At least one of the historical samples were collected when the ditch was not flowing, allowing more contact time and area with on-site slag material. In addition, because the high concentrations obtained by the Ecology data were related to an abundance of sediment in the water and an unknown sampling location, we do not believe these are representative of current or recent site conditions.

Source of Metals to the OFA Ditch

Surface water runoff from the slag-containing fill area appears to be the primary source of metals to the OFA Ditch surface water. This is based on the following data which indicate runoff is the principal source of water to the ditch, and suspended solids in the ditch water comprises a substantial portion of the metal load:

- ▶ Groundwater discharge volumes represent less than 1 percent of the total wet season flow in the ditch based on groundwater discharge estimates of 0.5 gpm through the OFA/Pennwalt Area in the wet season (Hart Crowser, 1992) and the flows measured (30 to 60 gpm) during our recent sampling event.
- ▶ Total metal concentrations exceed the dissolved metal concentrations in all cases with particulates representing at least 30 percent and up to 88 percent of the metal load. At the culvert, particulate arsenic ranged between 31 and 65 percent of the detected arsenic and particulate copper ranged between 37 and 88 percent of the metal in the surface water discharge.

Groundwater may act as a secondary source of metals to the OFA Ditch surface waters. Although only minor amounts of groundwater discharge to the ditch, samples from the head of the ditch (OFA-SW-392 and OFA-SW-492) near the Pennwalt Ag-Chem (Atochem) fenceline indicated low concentrations of metals. As discussed in the Blair Backup Property Final Investigation Report (Hart Crowser,

1992), this area contains elevated metal concentrations related to high pH levels in the groundwater. Extension of the ditch into this area may have allowed for a groundwater source of these metals to the drainage ditch.

The slag in the OFA/Pennwalt Area, particularly Asarco slag, is the likely source of the particulate arsenic, copper, and lead. A greater amount of Asarco slag was noted in the area around the OFA Ditch than elsewhere in the OFA/Pennwalt Area. In addition, these are the principal metals known to be leachable from Asarco slag in other Port of Tacoma log yards. The copper may also be related to the OFA slag as the OFA slag was shown to contain a substantial amount of copper (Hart Crowser, 1992, Volume II, Appendix F).

Impact to the Kaiser Ditch and Hylebos Waterway

Because of OFA Ditch water discharge to the Kaiser Ditch, and ultimately the Hylebos Waterway, the metal concentrations were also compared to marine aquatic life criteria to assess the potential for off-site impacts. The data indicate the surface water discharge of arsenic, copper, and lead from the OFA Ditch will not significantly impact the Kaiser Ditch or the Hylebos Waterway due to the following factors:

- ▶ Surface water in the OFA Ditch only flows off site during a portion of the wet season and during storm events;
- ▶ Measured surface water discharge rates in the OFA Ditch (0 to 60 gpm) are one to two orders of magnitude lower than discharge rates measured by Ecology (1984) in the Kaiser Ditch (1,040 to 1,950 gpm). Based on these discharge rates, surface water exiting the OFA Ditch will likely be diluted (mixed) by roughly 20 to over 100 times before reaching the Hylebos Waterway. At this mixing rate, arsenic, copper, and lead concentrations will be well below MTCA marine surface water cleanup levels;
- ▶ Arsenic, copper, and lead were not detected in Kaiser Ditch surface water samples during the most recent sampling event conducted as part of the Remedial Investigation (RI) for the 3009 Taylor Way property (ENSR, 1990); and
- ▶ Clean soil cover planned to fill the site will eliminate slag particulates in the surface water discharges and will reduce contact time with the slag reducing potential dissolution of metal.

Conclusions

Copper and lead are the only metals that exceed MTCA freshwater cleanup levels and generally exceed these criteria only on a total or non-filtered basis. The presence of these metals is not expected to significantly impact the environment because the ditch only flows during a small portion of the year and will be diluted by at least 20 to 100 times at its point of discharge to the Kaiser Ditch. Although dissolved metals concentrations generally meet MTCA freshwater cleanup levels under normal drainage conditions, historical data indicate that dissolved copper and lead concentrations may exceed MTCA freshwater criteria during periods in which the ditch becomes blocked resulting in increased contact time between the surface water and slag-containing fill materials.

Based on the findings of this work, we recommend that surface water runoff from the site be controlled to reduce contact time with the slag-containing fill material and minimize the transport of particulates. The reduction of particulates in the OFA Ditch will likely lower copper and lead concentrations to below MTCA freshwater cleanup levels. Placing a layer clean fill material over the OFA/Pennwalt Area (including the OFA Ditch channel) and improving drainage will also reduce surface water/fill contact time resulting in a further reduction of metal concentrations in OFA Ditch surface water.

References

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Ecology, 1985. Memorandum to Jim Krull from Norton and Johnson dated February 27, 1985, regarding completion report on WQIS Project 1 for the Commencement Bay Nearshore Tidelands Remedial Investigation: Assessment of Log Sort Yards as Metal Sources to Commencement Bay Waterways, November 1983 - June 1984.

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Hart Crowser, 1986. Results of Subsurface Explorations and Metals Testing, Cascade Timber Yard No. 2; prepared for Port of Tacoma, December 5, 1986.

Hart Crowser, 1992. Final Investigation Report, Blair Backup Property, Port of Tacoma, Washington, prepared for Port of Tacoma, dated January 29, 1992, J-2350-07.

Metro, 1982. Toxicants in Urban Runoff, Metro Toxicant Program Report No. 2 (by D.V. Galvin and R.K. Moore).

Tetra Tech, 1985. Commencement Bay Nearshore/Tideflats Remedial Investigation Report; prepared for U.S. Environmental Protection Agency and Washington Department of Ecology.

Table C-1 - Summary of Historical Surface Water Quality Data Collected from the OFA/Pennwalt Area

Sample Location: Date Sampled:	Cascade Timber Yard #2 Dec 1983	Cascade Timber Yard #2 June 1984	SW-2/OFA Jan 1990	SW-3/OFA Jan 1990	SW-1/OFA Jan 1991 Ponded
Flow in GPM	3.5	45	NA	NA	0
Total Metals in µg/L (ppb)					
Antimony	1 U	155	23 J	16 J	15
Arsenic	122	4,790	68	24	230
Beryllium	NA	NA	1 U	1 U	1 U
Cadmium	0.2 R	15.5	21	7	1 U
Chromium	NA	NA	19	8	5
Copper	33 R	4,000	240	64	61
Lead	23 R	4,940	46	10 U	14
Manganese	NA	NA	3 U	3 U	320
Mercury	NA	NA	1 U	1 U	1.0 U
Molybdenum	NA	NA	50 U	50 U	12
Nickel	22	325	15	7	7
Selenium	NA	NA	5 U	5 U	5 U
Silver	NA	NA	1 U	1 U	1 U
Thallium	NA	NA	5 UJ	5 UJ	2 U
Zinc	59 R	5,340	150	53	74
Dissolved Metals in µg/L (ppb)					
Antimony	NA	NA	NA	NA	15
Arsenic	NA	NA	NA	NA	180
Beryllium	NA	NA	NA	NA	1 U
Cadmium	NA	NA	NA	NA	1 U
Chromium	NA	NA	NA	NA	3
Copper	NA	NA	NA	NA	42
Lead	NA	NA	NA	NA	6.9
Manganese	NA	NA	NA	NA	310
Mercury	NA	NA	NA	NA	1.0 U
Molybdenum	NA	NA	NA	NA	12
Nickel	NA	NA	NA	NA	6
Selenium	NA	NA	NA	NA	5 U
Silver	NA	NA	NA	NA	1 U
Thallium	NA	NA	NA	NA	2 U
Zinc	NA	NA	NA	NA	62
Other Parameters					
Hardness as CaCO ₃ in mg/L	NA	NA	NA	NA	38
Total Suspended Solids in mg/L	27	7,800	87 J	23 J	16
Total Dissolved Solids in mg/L	NA	NA	690 J	250 J	NA

Notes:

U Indicates compound was analyzed for but not detected at the given detection limit.

J Indicates an estimated value.

B Indicates analyte was detected in laboratory method blank.

R Data was rejected due to field blank contamination.

GPM Gallons per minute.

NA Not analyzed.

2350T-C1.wk1

Table C-2 - Summary of Spring 1992 Surface Water Results Collected from the OFA Ditch

	OFA-SW-	OFA-SW-	OFA-SW-	OFA-SW-	OFA-SW-	MTCA Method B	Residential	MTCA Method B
Sample ID:	392-1	392-2	392-3	492-1	492-2	Freshwater	Stormwater Runoff	Marine Surface
Collection Date:	3/9/92	3/9/92	(Rep of 392-1)	4/17/92	4/17/92	Cleanup	Average	Water Cleanup
						Levels (a,c)	Concentrations (b)	Levels (a,e)
Flow in GPM	30	23	30	60	NA	---	---	---
Total Metals in µg/L								
Arsenic	140	82	160	120	110	190	13	36
Cadmium	1 U	1	1 U	1 U	1 U	2	0.7	9.3
Chromium	9	7	8	7	9	11 (d)	8	50 (d)
Copper	50	20	50	51	49	22	20	2.9
Iron	11000	20000	11000	2700	5300	---	---	---
Lead	8	7	9	9	10	8	210	5.6
Manganese	2100	1900	2100	390	610	---	---	---
Nickel	7	3	7	8	8	300	12	8.3
Zinc	39	28	43	82	60	200	115	86
Dissolved Metals in µg/L								
Arsenic	54	33	51	83	76	---	---	---
Cadmium	1 U	1 U	1 U	1 U	1 U	---	---	---
Chromium	8	5	8	5	7	---	---	---
Copper	7	1	5	32	21	---	---	---
Iron	1100	12000	960	1500	4200	---	---	---
Lead	1	1 U	2	3	5	---	---	---
Manganese	2000	1800	2100	400	650	---	---	---
Nickel	8	4	7	6	7	---	---	---
Zinc	26	17	25	71	50	---	---	---
Other Parameters								
Hardness as CaCO3 in mg/L	290	380	320	54	100	---	---	---
Total Dissolved Solids in mg/L	480	470	470	200	280	---	---	---
Total Suspended Solids in mg/L	39	66	38	11	18	---	---	---
Temperature in °C	8.0	14.5	8.0	12.2	13.6	---	---	---
pH	7.8	7.2	7.7	7.4	7.4	---	---	---
Specific Conductivity in µMhos	720	740	710	370	350	---	---	---
Dissolved Oxygen in mg/L	---	---	---	8.9	7.1	---	---	---

Notes:

NA Not able to analyze.

U Not detected at indicated detection limit.

GPM Gallons per minute.

(a) Ecology, February 1991, MTCA Cleanup Levels (Chapter (173-340-730 WAC).

(b) Samples were collected in Bellevue, Washington, as part of Metro's Toxicants in Urban Runoff Study (December 1982).

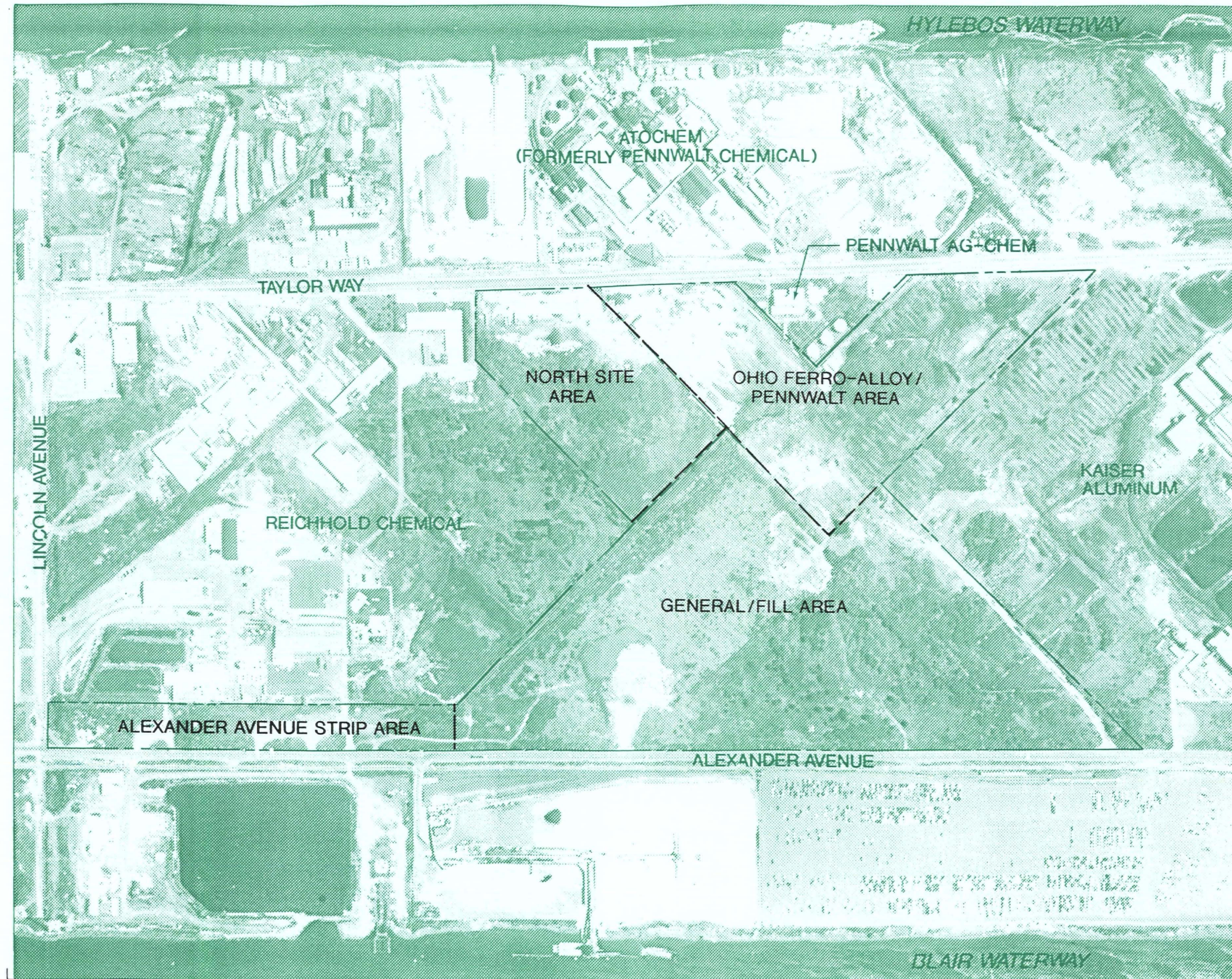
(c) Based on Clean Water Act freshwater aquatic life chronic toxicity criterion (Hardness = 210 mg/L as CaCO3).

(d) For hexavalent chromium only, cleanup level for trivalent chromium is 210 µg/L.

(e) Based on Clean Water Act marine aquatic life chronic toxicity criterion.

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Property Areas Map



Note: Base map prepared from aerial photograph of the Port of Tacoma dated June 1, 1989.

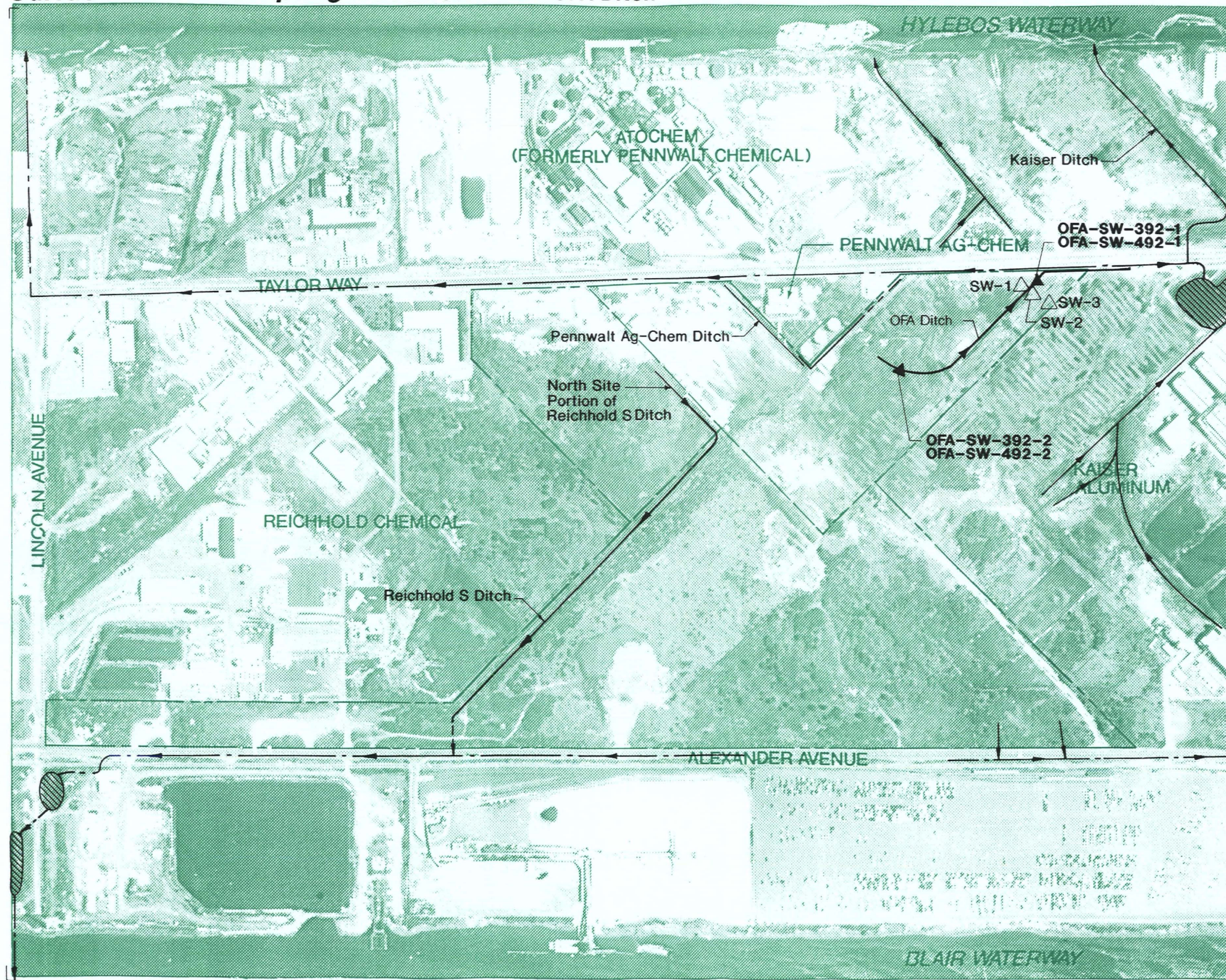


0 400 800
Approximate Scale in Feet



HARTCROWSER
J-2350-20 6/92
Figure C-1

Surface Water Sampling Location Plan OFA Ditch



- ▲ OFA-SW-392-2 Surface Water Sampling Location
- ← Closed Surface Water Drainage
- ← Open Surface Water Drainage
- △ SW-1 Approximate Location of Previous Surface Water Sampling Points

- Notes:
1. Ditch has been reconstructed at slightly different locations several times over the past few years to improve site drainage.
 2. Off-site drainage data obtained from the Commencement Bay-Nearshore/Tideflats Area Drainage Map (TPCHD, 1988) with modifications based on January 1991 observation
 3. Base map prepared from aerial photograph of the Port of Tacoma dated June 1, 1989.



0 400 800
Approximate Scale in Feet

APPENDIX D
***IN SITU* CHARACTERISTICS OF THE SOIL/SLAG MATERIAL IN THE**
OFA/PENNWALT AREA - SUPPLEMENTAL SITE ASSESSMENT

APPENDIX D

IN SITU CHARACTERISTICS OF THE SOIL/SLAG MATERIAL IN THE OFA/PENNWALT AREA - SUPPLEMENTAL SITE ASSESSMENT

This appendix describes the purpose, scope, and conclusions of the additional site assessment activities conducted on the Blair Backup property located in the Port of Tacoma, Washington. The purpose of this supplemental site assessment, as described in detail in the following section, was to gain additional information on the *in situ* characteristics and quantities of the soil/slag material in the OFA/Pennwalt Area. This information was needed to assist in completion of the analysis of alternatives.

Exploration, sampling, quality assurance, and health and safety procedures used were documented in the December 4, 1989, Final Work Plan and January 8, 1990, Revised Health and Safety Plan.

Introduction

Purpose Was to Quantify Slag-Containing Soil, and Slag Sources, Extent, and Physical Properties

The purpose of this task was to better quantify the *in situ* thickness, lateral extent, and hence volume of soil/slag material in the OFA/Pennwalt Area. A better understanding of the physical properties (most specifically, grain size, organic content, and moisture content) of this soil/slag material was also a purpose of this task.

Information on the physical (i.e., geotechnical) properties of the soil/slag fill helped us establish engineering characteristics of the material. The engineering characteristics of the fill together with the knowledge of its extent, assisted in our alternatives evaluation. This information is used in evaluating the technical feasibility associated with:

- ▶ Segregation of wood from mineral portion;
- ▶ Stabilization of metals;
- ▶ Segregation of charcoal from mineral portion; and
- ▶ General ability of the on-site material to be reworked, regraded, and recompacted.

Also as part of our work we visually assessed and tested the relative percentages of OFA slag and Asarco slag.

Scope of Work

Geotechnical Properties of Fill Material. We completed 20 test pits (TP-600 through TP-619) within the OFA/Pennwalt Area and the General/Fill Area as shown on Figure D-1. Logs of these test pits are presented in Attachment D-1. Some sampling was done in the area of the border between the OFA/Pennwalt Area and the General/Fill Area. Some of the test pits were advanced in previously explored areas in order to provide samples for the physical testing which are representative of the site as a whole. We completed test pits to depths below the soil/slag fill where possible. We collected samples of the soil/slag material from the test pits, transferred the samples to our laboratory and performed grains size analyses, moisture content determinations, and organic content determinations.

Differentiation of OFA and Asarco Slags. We attempted to differentiate Asarco slag from OFA slag. As part of our grain size analyses we dry sieved representative composite samples from six test pits (TP-603, TP-606, TP-607, TP-609, TP-611, and TP-614). These test pits were selected as being representative of the site from the total number of test pits excavated. The samples (4-gallon buckets) were composited from the full depth of the test pit at each location. The material retained on the ¼-inch sieve was visually sorted by slag type and the individual fractions were weighed.

Visual observations of surface soils was another method used for estimating the percent slag at the site. This generalized method was used to cross check estimates of percent slag at the surface with measured percentages of slag at depth. See Figure D-1 for location of the eight test areas designated SA-1 through SA-8. At different 12 foot by 12 foot areas the slag was visually estimated as a percentage of the whole square. These 12 foot by 12 foot squares were randomly located across the site in non-vegetated areas where at least one slag piece was identified. Each slag material was spray-painted to distinguish it from the wood chips and gravel. The Asarco slag and the OFA slag were painted different colors. Using a ladder, the percentage of painted material in the square areas were compared to the "Mineralogy Chart for Estimating Visual Percentage Composition of Rocks and Sediments," from the Journal of Sedimentary Petrology (v. 25, pp. 229-234, 1955). The percentages were based on volume, not weight.

OFA/Asarco Slag Extent in the OFA/Pennwalt Area

Figure D-2 outlines the extent of the slag as observed in the subsurface explorations. Figure D-3 shows the top and bottom depths of the slag material. Figure D-4 shows the thickness of the slag material. Reviewing the logs and the figures the following is concluded:

- ▶ The soil/slag material is found beneath roughly 12 to 13 acres of the site.
- ▶ Approximately 80,000 cubic yards (CY) of soil/slag material are present in the OFA/Pennwalt Area.
- ▶ The soil/slag material typically occurs from a depth of 0 to 4 feet below grade in the eastern half of the site and 0 to 6 feet below grade in the western half of the site.
- ▶ The soil/slag material averages 3 to 4 feet thick, thinner to the east thickening to the west. Thicknesses of eight feet were observed in some areas.

Constituents of the Soil/Slag Material

Test Pit/Laboratory Data. Laboratory analyses indicate that the constituents of this soil/slag mixture are roughly estimated to be (by total dry weight):

- ▶ 30 to 35 percent OFA slag;
- ▶ 1 to 2 percent Asarco slag;
- ▶ 8 to 10 percent organics;
- ▶ 1 to 2 percent miscellaneous debris; and
- ▶ 51 to 60 percent soil.

The soil is typically a slightly silty to silty, gravelly sand to sandy gravel with cobbles. The organics consist primarily of wood chips. Miscellaneous debris includes concrete rubble, lumber, metal, etc.

Visual Surficial Estimates. Table D-1 summarizes the observed percentages of slag material in the upper one to two inches at the site.

The overall percent of slag observed at the surface ranged from 1 to 10 percent, depending on how disturbed the soils were. The relatively undisturbed areas (no recent tilling or mounds of soil) had very little exposed slag (1 to 5 percent). The majority of the surface soils were well rounded gravel and wood chips with scattered

slag debris. The Asarco slag tended to be more abundant in the heavily wood chipped areas, and the OFA slag tended to be more abundant with the Quartz debris.

The northeast portion of the site tended to have more Asarco slag exposed at the surface. The percent of Asarco slag ranged from 1 to 8 percent and OFA slag ranged from 2 to 5 percent in this area. The southwest portion of the debris area was dominated by OFA slag at the surface with concentrations ranging form 3 to 8 percent.

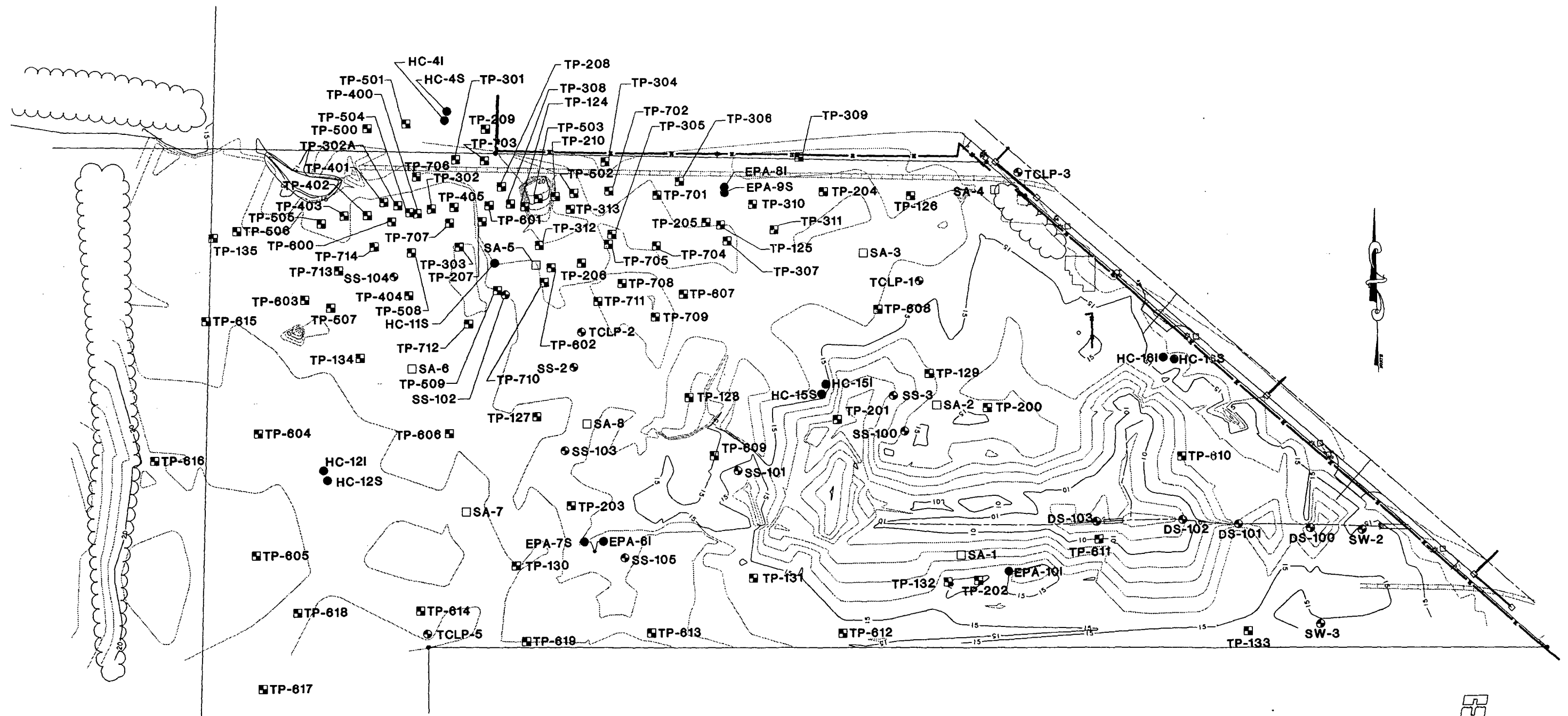
Table D-1 - Estimated Slag Content of Surficial Soils

Test Location Number	Estimated OFA Slag in Percent	Estimated Slag in Percent
SA-1	5	1
SA-2	2	5
SA-3	—	3
SA-4	3	7
SA-5	9	—
SA-6	4	1
SA-7	—	<1
SA-8	3	3

Site and Exploration Plan

Blair Backup Property, Eastern Arm, OFA/Pennwalt Area

- TP-131 Test Pit Location and Number (Hart Crowser, 1991)
- TP-606 Test Pit Location and Number (Current Study)
- HC-12S Monitoring Well Location and Number (Hart Crowser, 1991)
- ⊕ SS-103 Surface Soil Sample Location and Number (Hart Crowser, 1991)
- ⊕ DS-101 Ditch Sediment Sample Location and Number (Hart Crowser, 1991)
- SA-1 Percent Surface Soil/Slag Analysis Location and Number

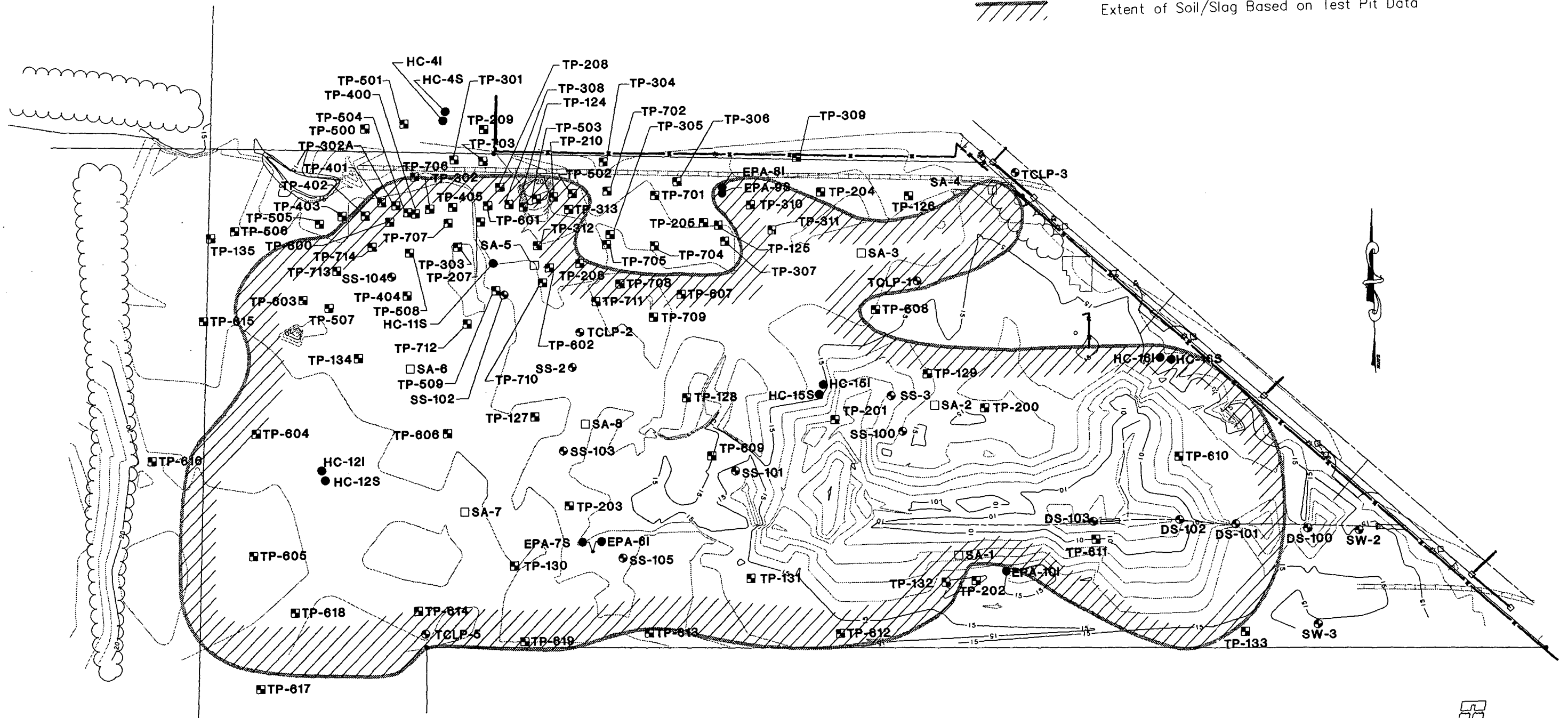


0 120 240
Scale in Feet

Soil/Slag Extent Plan

Blair Backup Property, Eastern Arm, OFA/Pennwalt Area

- TP-131 Test Pit Location and Number (Hart Crowser, 1991)
- TP-606 Test Pit Location and Number (Current Study)
- HC-12S Monitoring Well Location and Number (Hart Crowser, 1991)
- SS-103 Surface Soil Sample Location and Number (Hart Crowser, 1991)
- DS-101 Ditch Sediment Sample Location and Number (Hart Crowser, 1991)
- SA-1 Percent Surface Soil/Slag Analysis Location and Number
- Extent of Soil/Slag Based on Test Pit Data

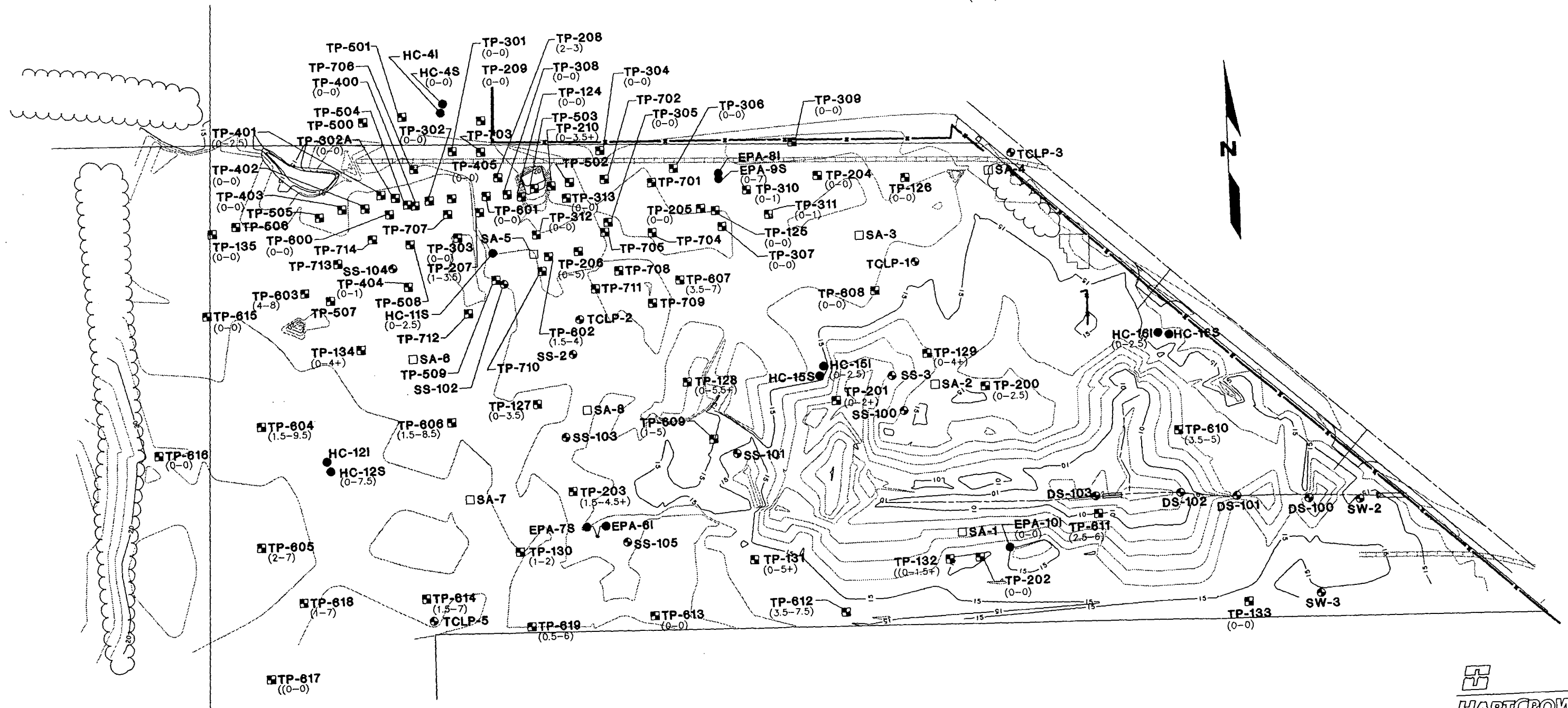


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Scale in Feet

Soil/Slag Top and Bottom Depths Plan

Blair Backup Property, Eastern Arm, OFA/Pennwalt Area

- TP-131 Test Pit Location and Number (Hart Crowser, 1991)
- TP-606 Test Pit Location and Number (Current Study)
- HC-12S Monitoring Well Location and Number (Hart Crowser, 1991)
- SS-103 Surface Soil Sample Location and Number (Hart Crowser, 1991)
- DS-101 Ditch Sediment Sample Location and Number (Hart Crowser, 1991)
- SA-1 Percent Surface Soil/Slag Analysis Location and Number
- (0-1) Soil/Slag Top and Bottom Depth below Grade in Feet

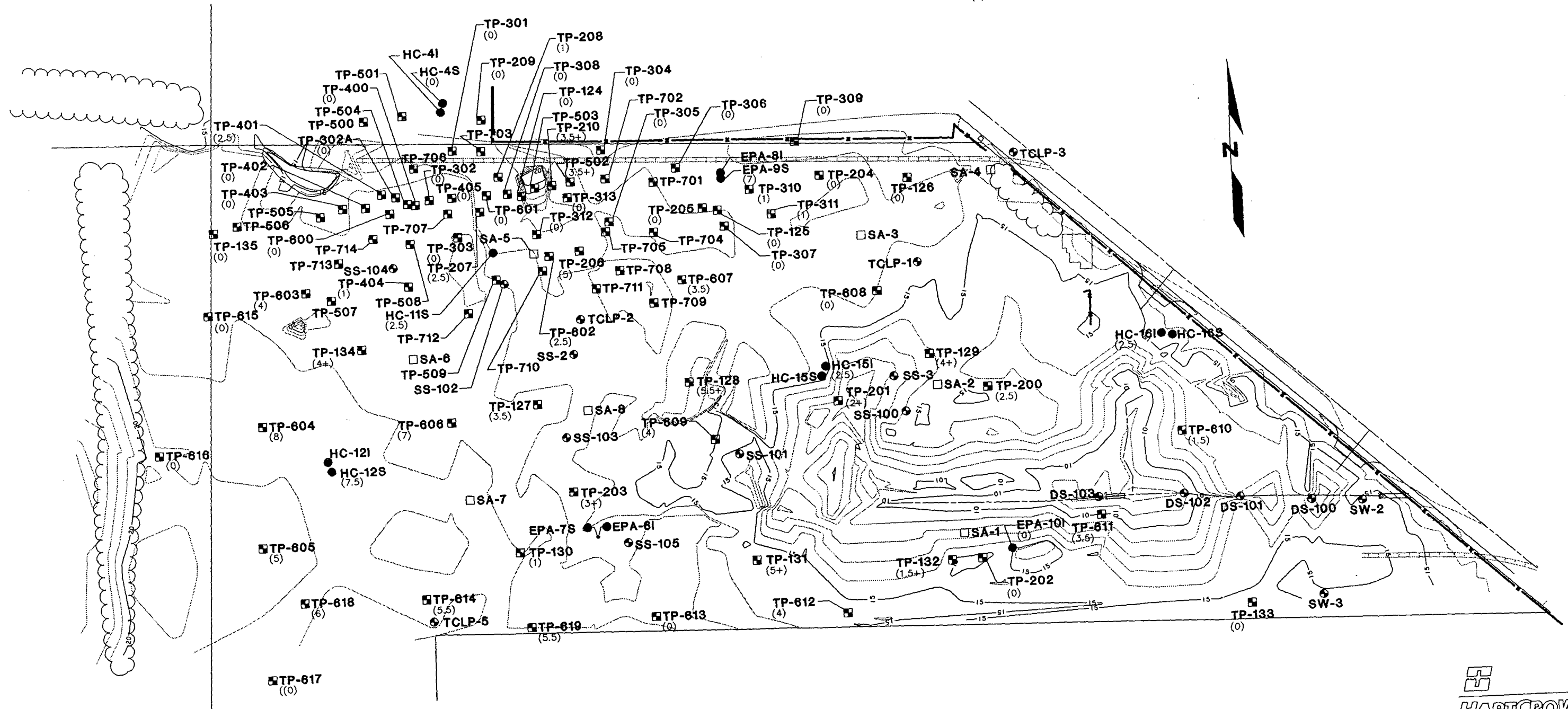


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Scale in Feet

Soil/Slag Thickness Plan

Blair Backup Property, Eastern Arm, OFA/Pennwalt Area

- | | |
|----------|--|
| ■ TP-131 | Test Pit Location and Number (Hart Crowser, 1991) |
| ■ TP-606 | Test Pit Location and Number (Current Study) |
| ● HC-12S | Monitoring Well Location and Number (Hart Crowser, 1991) |
| ● SS-103 | Surface Soil Sample Location and Number (Hart Crowser, 1991) |
| ● DS-101 | Ditch Sediment Sample Location and Number (Hart Crowser, 1991) |
| □ SA-1 | Percent Surface Soil/Slag Analysis Location and Number |
| (1) | Soil/Slag Thickness in Feet |



0 120 240
Scale in Feet

Hart Crowser
J-2350-20

ATTACHMENT D-1
FIELD EXPLORATIONS METHODS AND ANALYSIS

ATTACHMENT D-1

FIELD EXPLORATIONS METHODS AND ANALYSIS

This attachment documents the processes Hart Crowser uses in determining the nature of the soils underlying the project site addressed by this appendix. The discussion includes information on the following subjects:

- ▶ Explorations and Their Location
- ▶ Excavation of Test Pits

Explorations and Their Location

Subsurface explorations for this project include completing a series of test pits. The exploration logs within this appendix show our interpretation of the excavation, sampling, and testing data. They indicate the depth where the soils change. Note that the change may be gradual. In the field, we classified the samples taken from the explorations according to the methods presented on Figure D-1-1 - Key to Exploration Logs. This figure also provides a legend explaining the symbols and abbreviations used in the logs.

Location of Explorations. Figure D-1 shows the location of explorations, located by hand taping or pacing from existing physical features (property corners and surveyed wells). The ground surface elevations at these locations were interpreted from elevations shown on "Topographic Survey of A Portion of Parcel No. 9, Port of Tacoma" completed by HCE August 8, 1991. The method used determines the accuracy of the location and elevation of the explorations.

Excavation of Test Pits

A series of 20 test pits, designated TP-600 through TP-619, were excavated across the site with a tractor-mounted backhoe subcontracted by our firm. The sides of these excavated pits offer direct observation of the subgrade soils. The test pits were located by and excavated under the direction of an engineering geologist from Hart Crowser. The geologist observed the soil exposed in the test pits and reported the findings on a field log. Our geologist took representative samples of soil types for testing at Hart Crowser's laboratory. He noted groundwater levels or seepage during excavation. The density/consistency of the soils (as presented parenthetically on the test pit logs to indicate their having been estimated) is based on visual observation only as disturbed soils cannot be measured for in-place density in the laboratory.

The test pit logs are presented on Figures D-1-2 through D-1-11.

Key to Exploration Logs

Sample Descriptions

Classification of soils in this report is based on visual field and laboratory observations which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field nor laboratory testing unless presented herein. Visual-manual classification methods of ASTM D 2488 were used as an identification guide.

Soil descriptions consist of the following:

Density/consistency, moisture, color, minor constituents, MAJOR CONSTITUENT, additional remarks.

Density/Consistency

Soil density/consistency in borings is related primarily to the Standard Penetration Resistance. Soil density/consistency in test pits is estimated based on visual observation and is presented parenthetically on the test pit logs.

SAND or GRAVEL	Standard Penetration Resistance in Blows/Foot	SILT or CLAY	Standard Penetration Resistance in Blows/Foot	Approximate Shear Strength in TSF
Density		Consistency		
Very loose	0 - 4	Very soft	0 - 2	<0.125
Loose	4 - 10	Soft	2 - 4	0.125 - 0.25
Medium dense	10 - 30	Medium stiff	4 - 8	0.25 - 0.5
Dense	30 - 50	Stiff	8 - 15	0.5 - 1.0
Very dense	>50	Very stiff	15 - 30	1.0 - 2.0
		Hard	>30	>2.0

Moisture

Dry	Little perceptible moisture
Damp	Some perceptible moisture, probably below optimum
Moist	Probably near optimum moisture content
Wet	Much perceptible moisture, probably above optimum

Minor Constituents

Minor Constituents	Estimated Percentage
Not identified in description	0 - 5
Slightly (clayey, silty, etc.)	5 - 12
Clayey, silty, sandy, gravelly	12 - 30
Very (clayey, silty, etc.)	30 - 50

Legends

Sampling

BORING SAMPLES

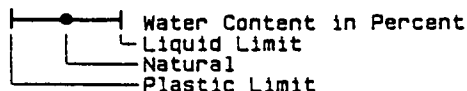
- ☒ Split Spoon
- ☒ Shelby Tube
- ☒ Cuttings
- ☒ Core Run
- * No Sample Recovery
- P Tube Pushed, Not Driven

TEST PIT SAMPLES

- ☒ Grab (Jar)
- ☒ Bag
- ☒ Shelby Tube

Test Symbols

- GS Grain Size Classification
- CN Consolidation
- TUU Triaxial Unconsolidated Undrained
- TCU Triaxial Consolidated Undrained
- TCD Triaxial Consolidated Drained
- QU Unconfined Compression
- DS Direct Shear
- K Permeability
- PP Pocket Penetrometer
- TV Torvane
- CBR California Bearing Ratio
- MD Moisture Density Relationship
- AL Atterberg Limits



Ground Water Observations

- Surface Seal
- Ground Water Level on Date (ATD) At Time of Drilling
- Observation Well Tip or Slotted Section
- Ground Water Seepage (Test Pits)



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Figure D-1-1

Log of Test Pit TP-600

Sample Number (Lab Test)	Sample Depth in Feet	Stratum Depth in Feet	Soil Description
S-2	0 - 1½	0 - ½	(Soft), moist, black, sandy SILT.
S-1	1 - 2	½ - 4	(Loose), wet, dark brown, silty, sandy GRAVEL with moderate debris, including asphalt, wire logs with creosote-like staining. Petroleum odor.
S-3	2½ - 3		

Bottom of TP-600 at 4 feet completed 4/20/92.

Note: Groundwater encountered at depth of 3 feet. Hit concrete refusal at 4 feet.

Sample S-1 taken for chemical analysis.

Log of Test Pit TP-601

Sample Number (Lab Test)	Sample Depth in Feet	Stratum Depth in Feet	Soil Description
S-2	0 - 1	0 - 1	(Dense), moist, gray and brown, sandy GRAVEL with cobbles and charcoal briquettes.
S-3	2 - 2½	1 - 3	(Soft), moist, black, gravelly SILT with abundant wood-lumber debris and scattered metal debris.
GS-1	0-3		

Bottom of TP-601 at 3 feet completed 4/20/92.

Note: Groundwater was not encountered. Hit concrete refusal at 3 feet.

Log of Test Pit TP-602

Sample Number (Lab Test)	Sample Depth in Feet	Stratum Depth in Feet	Soil Description
S-2	0 - 2	0 - 2	(Loose), wet, black, gravelly, silty SAND with cobbles and slag material below 1.5 feet.
S-3	3½ - 4	2 - 4	(Loose), wet, gray-brown, sandy SILT with slag material.
GS-1			

Bottom of TP-602 at 4 feet, completed 4/20/92.

Note: Groundwater encountered at depth of 1.5 feet. Hit refusal (concrete slab) on several attempts. Refusal at 4 feet. Grab samples (GS-1) collected from 0 to 4 feet in four gallon bucket.

Log of Test Pit TP-603

Sample Number (Lab Test)	Sample Depth in Feet	Stratum Depth in Feet	Soil Description
S-1	0 - ½	0 - ½	(Loose), wet, dark brown, silty, gravelly SAND with wood chips.
S-2	½ - 1	½ - 3	(Dense), wet, dark brown, silty, sandy GRAVEL with abundant asphalt debris and trace wood debris.
S-3	3 - 4	3 - 4	(Stiff), moist, black, gravelly, sandy SILT with wood chips.
S-4	4 - 5	4 - 8	(Dense), wet, black, silty, sandy GRAVEL (with 60 percent quartz, 5 percent charcoal, 10 percent slag) also wood, and wire cable.
S-5	9½	8 - 9½	(Loose), wet, black gray, silty SAND with quartz and slag.
GS-1	0 - 9½		

Bottom of TP-603 at 9½ feet, completed 4/20/92.

Note: Groundwater encountered at 4 feet. Evidence of water migration below 4 feet.

Log of Test Pit TP-604

Sample Number (Lab Test)	Sample Depth in Feet	Stratum Depth in Feet	Soil Description
S-1	0 - ½	0 - ½	(Loose), wet, black, sandy, silty GRAVEL with cobbles.
S-2	½ - 1½	½ - 1½	(Dense), wet, brown, silty, gravelly SAND.
S-3	2 - 3	1½ - 9½	(Loose), moist, black, silty, gravelly SAND with 40 to 50 percent slag and trace quartz, wood chips, bricks, and a rubber tube.
		9½ - 10	(Loose), wet, brown-gray, sandy SILT.
GS-1	0 - 9½		

Bottom of TP-604 at 9½ feet, completed 4/20/92.

Note: Groundwater encountered at depth of 4 feet. Estimate 40 to 50 percent slab at bottom of test pit. Grab sample (GS-1) collected from 0 to 9½ feet in four gallon bucket.

TP-605

Sample Number (Lab Test)	Sample Depth in Feet	Stratum Depth in Feet	Soil Description
S-1	0 - ½	0 - ½	(Soft), wet black SILT with bark.
S-2	1 - 2	½ - 2	(Dense), moist, brown sandy GRAVEL with concrete debris.
S-3	2 - 3	2 - 7	(Loose), moist, black, gravelly, silty fine SAND with cobbles and trace slag (15 percent) from 2 to 4 feet and abundant slab below 4 feet.
S-4	7 - 8	7 - 9	(Soft), wet, dark gray, silty, medium SAND.
GS-1	0 - 9		

Bottom of TP-605 at 9 feet, completed 4/20/92.

Note: Groundwater encountered at depth of 5 feet.

TP-606

Sample Number (Lab Test)	Sample Depth in Feet	Stratum Depth in Feet	Soil Description
S-1	0 - ½	0 - ½	(Very loose), wet, brown-black, slightly gravelly SILT with abundant wood chips.
S-2	½ - 1¼	½ - 1½	(Dense), moist blackish, silty GRAVEL.
S-3	1¼ - 3½	1½ - 3½	(Dense), wet, black, gravelly medium SAND with trace slag and a layer of SILT at 1.2 feet.
		3½ - 8½	(Dense), wet, black, gravelly, medium SAND with slag, quartz, pipe, tin, wood, and wire debris.
S-4	8½	8½ - 9	(Soft), wet, brown SILT.
GS-1	0 - 8½		

Bottom of TP-606 at 9 feet, completed 4/20/92.

Note: Groundwater encountered at depth of 3.5 feet.

TP-607

Sample Number (Lab Test)	Sample Depth in Feet	Stratum Depth in Feet	Soil Description
S-1	0 - 1½	0 - 1½	(Loose), wet, dark-brown, sandy, silty GRAVEL with wood chips.
S-2	2 - 3	1½ - 7	(Dense), wet, gray, very sandy GRAVEL with slag (30 percent) and lumber debris.
S-3	7	7 - ½	(Soft), wet, dark gray slightly silty, medium SAND.
GS-1	0 - 7		

Bottom of TP-607 at 7½ feet, completed 4/20/92.

Note: Groundwater encountered at depth of 2 feet.

TP-608

Sample Number (Lab Test)	Sample Depth in Feet	Stratum Depth in Feet	Soil Description
S-1	½ - 1	0 - 2½	(Very loose), wet, black, gravelly SILT with wood chips.
S-2	2½ - 3	2½ - 3	(Very dense), green-gray, moist, silty, sandy GRAVEL with cobbles and trace quartz.

Bottom of TP-608 at 3 feet, completed 4/17/92.

Note: Groundwater encountered at depth of 2.5 feet. Hit concrete refusal at 3 feet in several locations.

TP-609

Sample Number (Lab Test)	Sample Depth in Feet	Stratum Depth in Feet	Soil Description
S-1	0 - 1	0 - 1	(Very soft), wet, black SILT with wood chips.
		1 - 5	(Dense), wet, black, very sandy GRAVEL with slag (50 to 60 percent) and cobbles.
		5 - 5½	(Loose), wet, medium SAND.
GS-1	0 - 5		

Bottom of TP-609 at 5½ feet, completed 4/17/92.

Note: Groundwater encountered at depth of 1½ feet and rose to the surface.

TP-610

Sample Number (Lab Test)	Sample Depth in Feet	Stratum Depth in Feet	Soil Description
S-1	0 - ½	0 - ½	(Very soft), moist, black SILT with abundant wood chips.
S-2	½ - 1½	½ - 5	(Dense), wet, brown to black sandy GRAVEL with cobbles, slag, quartz plus chunks of cement. Slag observed 3½ to 5 feet.
		5 - 5½	(Medium dense), wet, black silty SAND.
GS-1	0 - 5½		

Bottom of TP-610 at 5½ feet, completed 4/17/92.

Note: Groundwater encountered at depth of 2 feet.

TP-611

Sample Number (Lab Test)	Sample Depth in Feet	Stratum Depth in Feet	Soil Description
S-1	0 - ½	0 - ½	(Very soft), moist, black SILT with abundant wood chips.
S-2	½ - 1	½ - 1	(Dense), wet, brown, slightly sandy, coarse GRAVEL.
S-3 S-4	1 - 1½ 2 - 2½	1 - 2½	(Dense), wet, black-brown, sandy GRAVEL with cobbles.
		2½ - 6	(Dense), wet, black, sandy GRAVEL with slag (45 to 55 percent) and cobbles.
		6 - 6½	(Loose), wet, dark gray medium SAND.
GS-1	0 - 6		

Bottom of TP-611 at 6½ feet, completed 4/17/92.

Note: Groundwater encountered at depth of 3½ feet.

TP-612

Sample Number (Lab Test)	Sample Depth in Feet	Stratum Depth in Feet	Soil Description
S-1	0 - ½	0 - ½	(Loose), wet, black, silty, sandy GRAVEL.
S-2	½ - 1	½ - 1	(Dense), wet, gray sandy GRAVEL.
S-3	1 - 2	1 - 2	(Dense), wet, black, silty, sandy GRAVEL.
S-4	2 - 3½	2 - 7½	(Dense), wet, black, sandy GRAVEL mixed with cobbles and slag. Concrete and brick debris observed.
S-5	7½	7½ - 8	(Medium dense), black, silty SAND.
GS-1	0 - 7½		

Bottom of TP-612 at 8 feet, completed 4/17/92.

Note: Groundwater encountered at depth of 4½ feet.

TP-613

Sample Number (Lab Test)	Sample Depth in Feet	Stratum Depth in Feet	Soil Description
S-1	0 - ½	0 - ½	(Very soft), wet, black SILT.
S-2	½ - 2	½ - 2	(Dense), wet, brown, gravelly, silty SAND.
		2 - 7½	(Loose), wet, black, silty, gravelly SAND with cobbles. Brick and metal debris at 2½ feet.
		7½ - 8	(Loose), wet, dark gray medium SAND.
GS-1	0 - 7½		

Bottom of TP-613 at 8 feet, completed 4/17/92.

Note: Groundwater encountered at depth of 2 feet. Hot water tank found at 2½ feet.

TP-614

Sample Number (Lab Test)	Sample Depth in Feet	Stratum Depth in Feet	Soil Description
S-1	0 - ½	0 - ½	(Loose), wet, black, silty, gravelly SAND.
S-2	½ - 1½	½ - 1½	(Dense), moist, brown sandy GRAVEL (pit run).
S-3	6½ - 7	1½ - 7	(Loose), wet, black, silty, gravelly SAND with quartz, traces of OFA slag (5 percent), wood and wire.
S-4	7½ - 8	7 - 9½	(Medium dense to loose), wet, dark gray, silty, medium SAND.
GS-1	0 - 9½		

Bottom of TP-614 at 9½ feet, completed 4/17/92.

Note: Groundwater encountered at depth of 9 feet.

TP-615

Sample Number (Lab Test)	Sample Depth in Feet	Stratum Depth in Feet	Soil Description
S-1	0 - ½	0 - ½	4 inches root mass over (medium dense), wet, black, silty, gravelly SAND with organics.
S-2	2 - 2½	1½ - 4	(Medium dense), moist to wet, brown, silty gravelly SAND with wood fragments and brick debris (fire bricks?).
S-3	4½ - 5	4 - 8	Wood chips (solid layer).

Bottom of TP-615 at 8 feet, completed 4/30/92.

Note: Groundwater seepage encountered at depth of 1½ feet. Groundwater at depth of 3 feet.

TP-616

Sample Number (Lab Test)	Sample Depth in Feet	Stratum Depth in Feet	Soil Description
		0 - 2½	2 inches root mass over (dense) moist, gray, gravelly SAND with asphalt debris.
S-1	6 - 6½	2½ - 8½	(Dense), moist, gray, silty, gravelly SAND with wood debris at 4 feet and tie wire debris at 7 feet.

Bottom of TP-616 at 8½ feet, completed 4/30/92.

TP-617

Sample Number (Lab Test)	Sample Depth in Feet	Stratum Depth in Feet	Soil Description
		0 - 1½	(Very dense), damp, brown, silty, sandy GRAVEL.
		1½ - 2	(Medium stiff), moist, brown, slightly clayey SILT with root fragments.
S-1	3 - 3½	2 - 6	(Medium dense), wet, black, silty, fine SAND with occasional cobbles.
		6 - 8	(Medium dense), wet, black, silty, fine SAND with dredge sand.

Bottom of TP-617 at 8 feet, completed 4/30/92.

Note: Heavy groundwater seepage encountered at depth of 3½ feet.

TP-618

Sample Number (Lab Test)	Sample Depth in Feet	Stratum Depth in Feet	Soil Description
		0 - 1	(Very dense), dry, brown, silty, sandy GRAVEL with cobbles.
G-1	1 - 5	1 - 7	(Medium dense), moist to wet, black, silty, sandy GRAVEL with cobbles and approximately 5 percent OFA slag.
S-1	8 - 8½	7 - 8½	(Medium dense), wet, black, silty, fine SAND.

Bottom of TP-618 at 8½ feet, completed 4/30/92.

Note: Groundwater seepage encountered at depth of 7 feet.

TP-619

Sample Number (Lab Test)	Sample Depth in Feet	Stratum Depth in Feet	Soil Description
		0 - ½	(Dense), moist, brown, silty, sandy GRAVEL with abundant cobbles and wood chips.
G-1	1 - 5	½ - 6	(Medium dense), moist to wet, black, silty, gravelly SAND with cobbles, quartz (5 percent), slag (5 to 10 percent), wood fragments (15 percent), and miscellaneous debris.
S-1	7 - 7½	6 - 8	(Medium dense), wet, black, silty, fine SAND.

Bottom of TP-619 at 8 feet, completed 4-30-92.

Note: Slight groundwater seepage encountered at depth of 7½ feet.

Hart Crowser
J-2350-20

ATTACHMENT D-2
LABORATORY TESTING PROGRAM

ATTACHMENT D-2 LABORATORY TESTING PROGRAM

A laboratory testing program was performed for this study to evaluate the basic index and geotechnical engineering properties of the site soils. Disturbed samples were tested. The tests performed and the procedures followed are outlined below.

Soil Classification

Field Observation and Laboratory Analysis. Soil samples from the explorations were visually classified in the field and then taken to our laboratory where the classifications were verified in a relatively controlled laboratory environment. Field and laboratory observations include density/consistency, moisture condition, and grain size and plasticity estimates.

The classifications of selected samples were checked by laboratory tests such as Atterberg limits determinations and grain size analyses. Classifications were made in general accordance with the Unified Soil Classification (USC) System, ASTM D 2487, as presented on Figure D-2-1.

Water Content Determinations

As soon as possible following their arrival in our laboratory, water contents were determined for most samples recovered in the explorations in general accordance with ASTM D 2216-90. Water contents were not determined for very small samples nor samples where large gravel contents would result in values considered unrepresentative. The results of these tests are presented at the respective sample depth on the exploration logs.

Grain Size Analysis (GS)

Grain size distribution was analyzed on representative samples in general accordance with ASTM D 422-63. Wet sieve analysis was used to determine the size distribution greater than the U.S. No. 200 mesh sieve. The size distribution for particles smaller than the No. 200 mesh sieve was determined by the hydrometer method for a selected number of samples. The results of the tests are presented as curves on Figures D-2-2 through D-2-6 plotting percent finer by weight versus grain size.

Organic Content

Organic content was analyzed on representative samples in general accordance with ASTM D 2974-87. Results are presented in Table D-2-1.

Table D-2-1 - Organic Content of Test Pit Samples

Exploration No.	Sample No.	Depth in Feet	Moisture Content in Percent	Organic Content in Percent
TP-601	GS-1	0 - 3	33	30
TP-602	GS-1	0 - 4	33	5
TP-603	GS-1	0 - 9.5	20	7
TP-604	GS-1	0 - 9.5	28	3
TP-605	GS-1	0 - 9	70	9
TP-606	GS-1	0 - 8.5	44	8
TP-607	GS-1	0 - 7	35	8
TP-609	GS-1	0 - 5	50	14
TP-610	GS-1	0 - 5.5	7	5
TP-611	GS-1	0 - 6	31	5
TP-612	GS-1	0 - 7.5	33	11
TP-614	GS-1	0 - 9.5	40	11
TP-618	G-1	1 - 5	46	10
TP-619	G-1	1 - 5	41	13

table.1

Unified Soil Classification (USC) System

Soil Grain Size

Size of Opening in Inches										Number of Mesh per Inch (US Standard)										Grain Size in Millimetres												
12	6	4	2	1-1/2	1	3/4	5/8	1/2	3/8	4	10	20	40	60	100	200	.06	.04	.03	.02	.01	.008	.006	.004	.003	.002	.001					
300	200	100	80	60	40	30	20	10	8	6	4	3	2	1	.8	.6	.4	.3	.2	.1	.08	.06	.04	.03	.02	.01	.008	.006	.004	.003	.002	.001
Grain Size in Millimetres																																

Grain Size in Millimetres

COBBLES	GRAVEL	SAND	SILT and CLAY
Coarse-Grained Soils			Fine-Grained Soils

Coarse-Grained Soils

G W	G P	G M	G C	S W	S P	S M	S C
Clean GRAVEL <5% fines		GRAVEL with >12% fines		Clean SAND <5% fines		SAND with >12% fines	
GRAVEL >50% coarse fraction larger than No. 4				SAND >50% coarse fraction smaller than No. 4			
Coarse-Grained Soils >50% larger than No. 200 sieve							

G W and S W $\left(\frac{D_{60}}{D_{10}}\right) > 4$ for G W & $1 \leq \left(\frac{D_{30}}{D_{10} \times D_{60}}\right) \leq 3$ G P and S P Clean GRAVEL or SAND not meeting requirements for G W and S W

G M and S M Atterberg limits below A Line with PI < 4

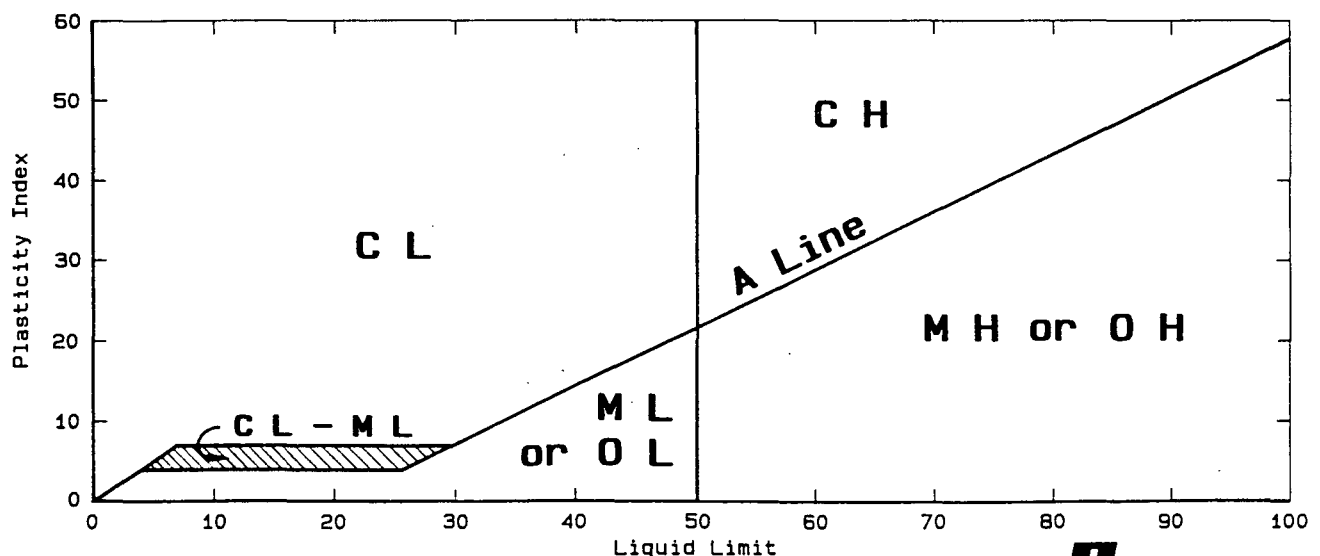
G C and S C Atterberg limits above A Line with PI > 7

* Coarse-grained soils with percentage of fines between 5 and 12 are considered borderline cases requiring use of dual symbols.

D₁₀, D₃₀, and D₆₀ are the particle diameter of which 10, 30, and 60 percent, respectively, of the soil weight are finer.

Fine-Grained Soils

M L	C L	O L	M H	C H	O H	Pt
SILT	CLAY	Organic	SILT	CLAY	Organic	Highly Organic Soils
Soils with Liquid Limit <50%			Soils with Liquid Limit >50%			
Fine-Grained Soils >50% smaller than No. 200 sieve						

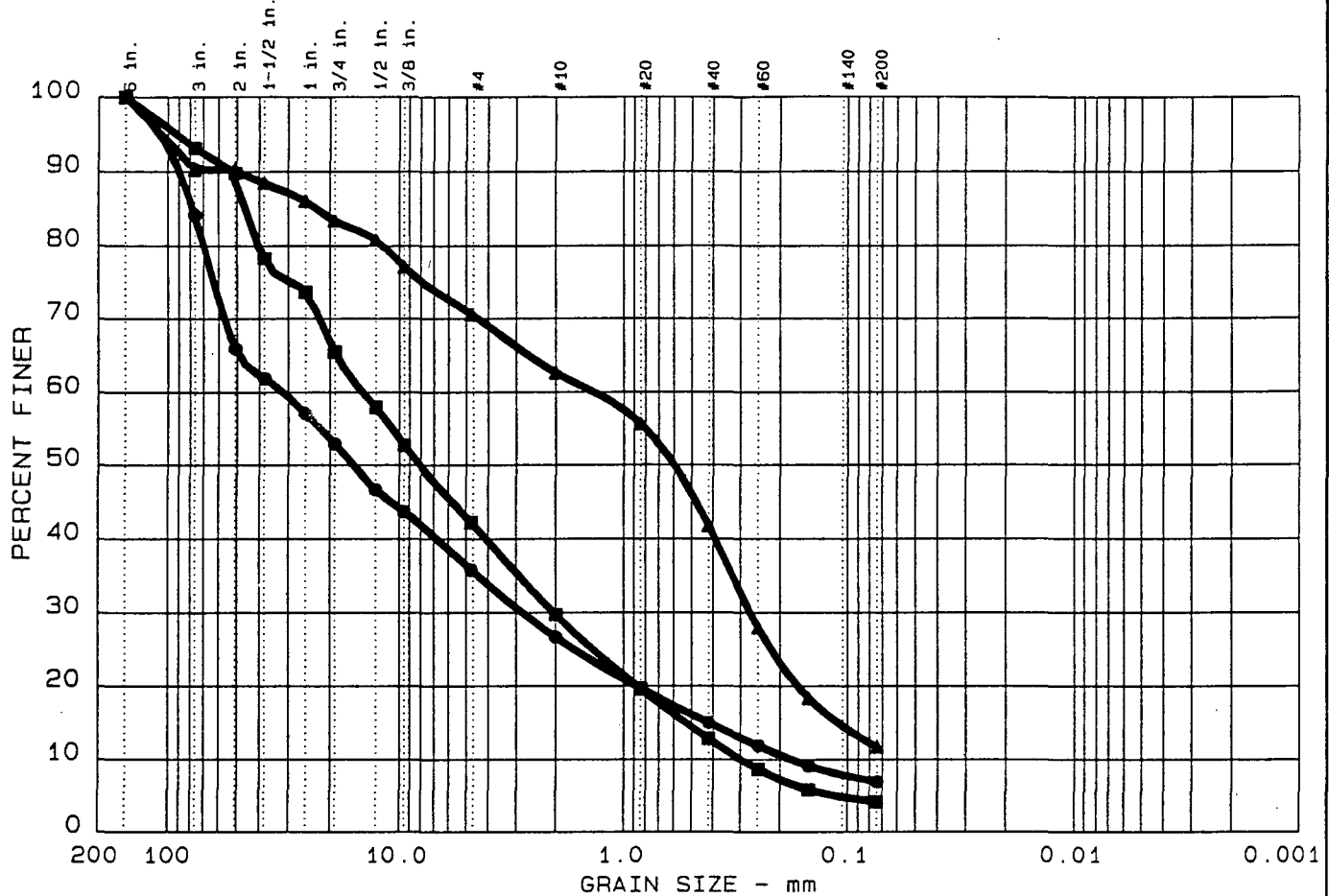


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J-2350-20 7/92

Figure D-2-1

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75 _{mm}	% GRAVEL	% SAND	% SILT	% CLAY
●	15.8	48.3	29.0	6.9	
▲	9.8	19.6	59.0	11.6	
■	6.8	50.9	38.1	4.2	

	LL	PI	D ₈₅	D ₆₀	D ₅₀	D ₃₀	D ₁₅	D ₁₀	C _c	C _u
●			77.62	31.62	15.85	2.786	0.4169	0.1758	1.40	179.9
▲			22.39	1.35	0.60	0.272	0.1107			
■			46.03	14.39	8.09	2.032	0.5284	0.2972	0.97	48.4

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● Slightly silty, sandy GRAVEL with cobbles	GW-GM	25%
▲ Slightly silty, gravelly SAND with cobbles	SP-SM	30%
■ Very sandy GRAVEL with cobbles	GP	23%

Remarks:

Project: Blair Backup

● Location: TP-601, GS-1, Depth: 0'-3'

▲ Location: TP-602, Depth: 0'-4'

■ Location: TP-603, GS-1, Depth: 0'-9.5'

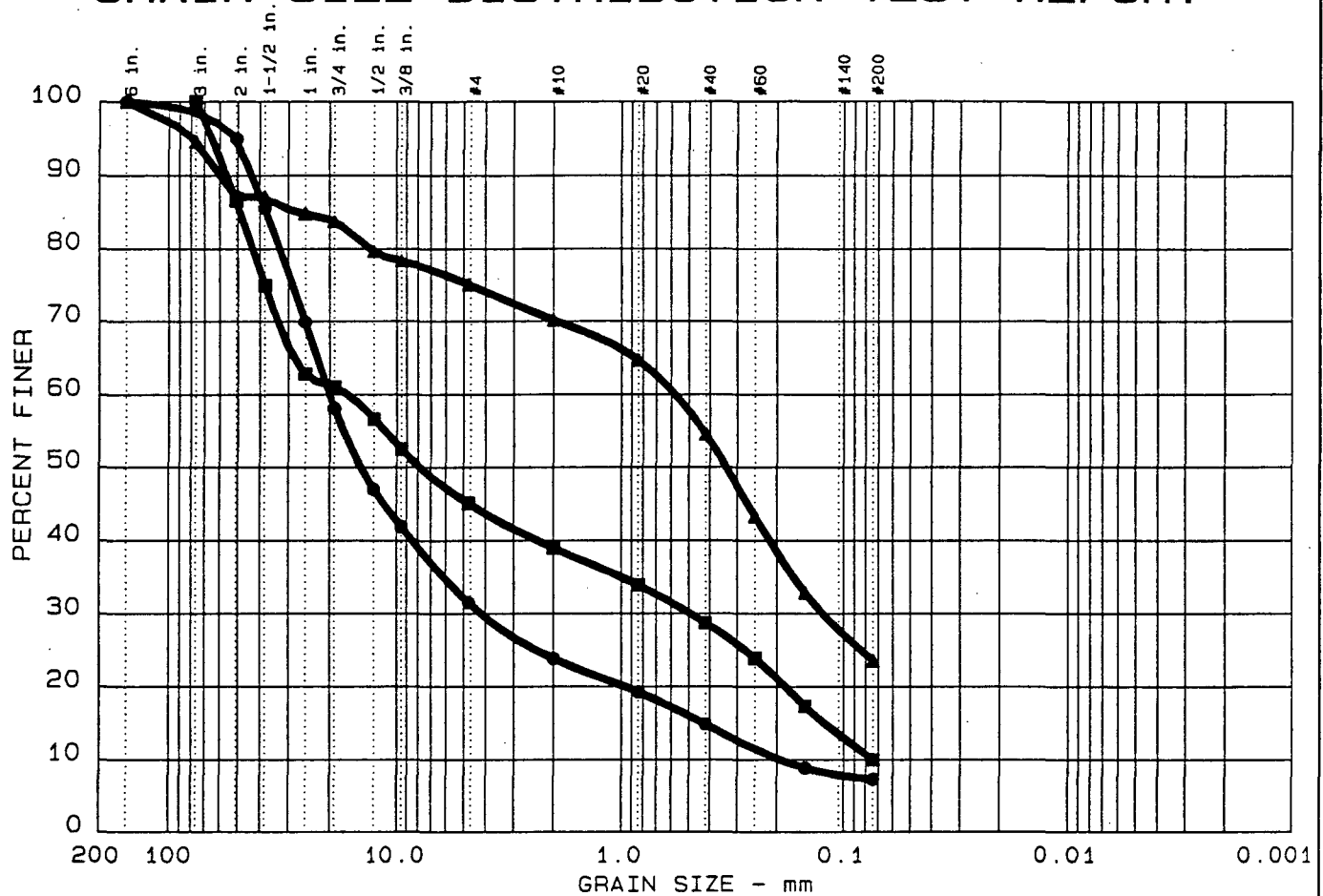


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Figure D-2-2

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75 mm	% GRAVEL	% SAND	% SILT	% CLAY
●	1.5	66.9	24.3	7.3	
▲	5.4	19.5	51.5	23.6	
■	0.0	54.9	35.1	10.0	

	LL	PI	D ₈₅	D ₆₀	D ₅₀	D ₃₀	D ₁₅	D ₁₀	C _c	C _u
●			37.50	19.91	14.42	4.159	0.4207	0.1923	4.52	103.5
▲			26.92	0.58	0.33	0.123				
■			48.70	16.50	7.81	0.487	0.1209			

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● Slightly silty, sandy GRAVEL	GP-GM	15%
▲ Gravelly, silty SAND with cobbles	SM	60%
■ Silty, very sandy GRAVEL	GP-GM	36%

Remarks:

Project: Blair Backup

● Location: TP-604

▲ Location: TP-605, Depth: 0'-9'

■ Location: TP-606, Depth: 0'-8.5'

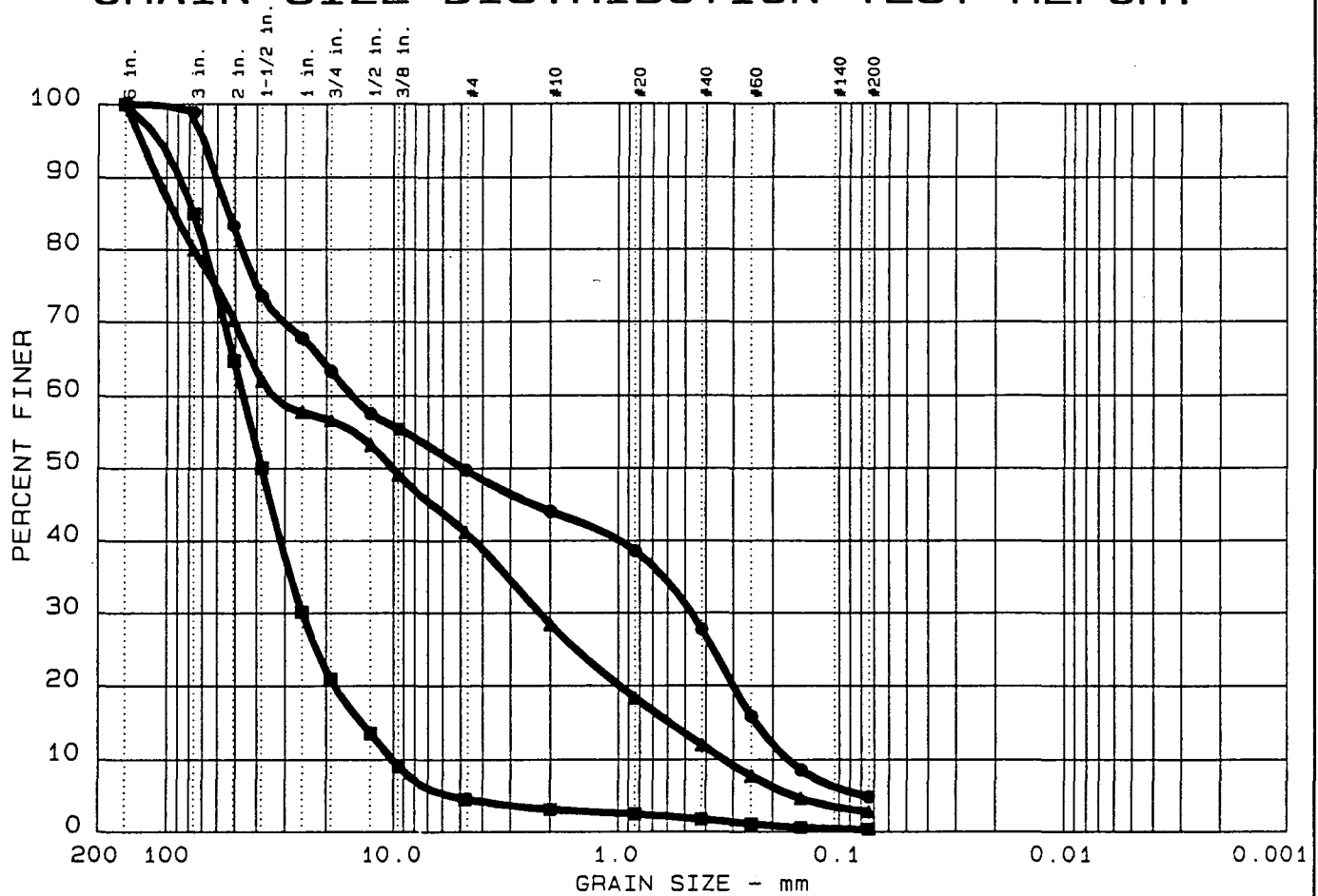


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Figure D-2-3

GRAIN SIZE DISTRIBUTION TEST REPORT



	% +75 mm	% GRAVEL	% SAND	% SILT	% CLAY
●	1.1	49.1	45.0	4.8	
▲	20.0	38.7	38.5	2.8	
■	15.0	80.4	4.2	0.4	

	LL	PI	D ₈₅	D ₆₀	D ₅₀	D ₃₀	D ₁₅	D ₁₀	C _c	C _u
●			53.09	15.31	4.84	0.468	0.2371	0.1698	0.08	90.2
▲			92.26	33.88	10.12	2.213	0.5888	0.3311	0.44	102.3
■			75.86	46.24	38.02	25.264	13.7246	10.0577	1.37	4.6

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● Very sandy GRAVEL	GP	39%
▲ Very sandy GRAVEL with cobbles	GP	39%
■ GRAVEL with cobbles	GW	7%

Remarks:

Project: Blair Backup

● Location: TP-607, Depth: 0'-7'

▲ Location: TP-609, GS-1, Depth: 0'-5'

■ Location: TP-610, Depth: 0'-5.5'

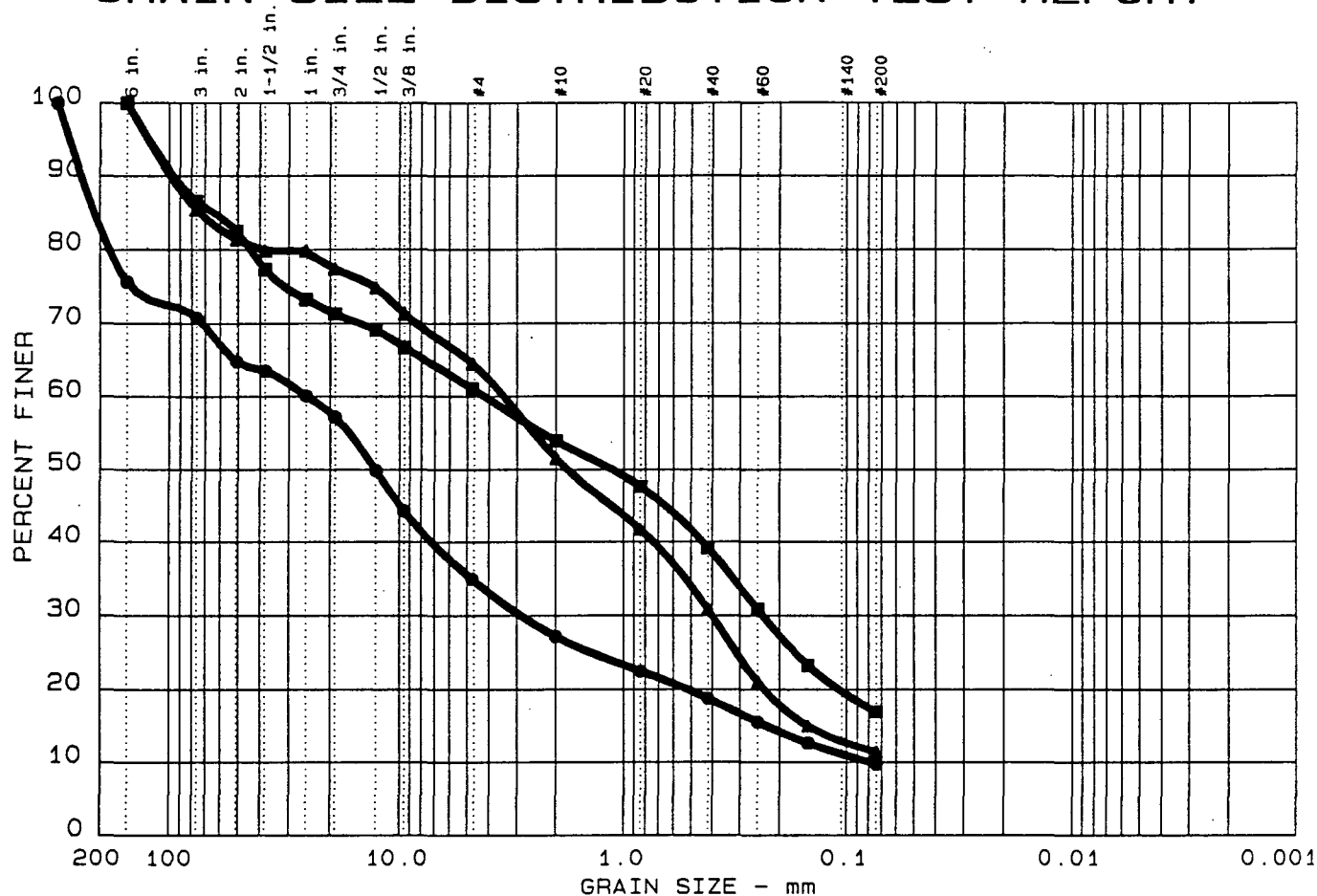


HART-CROWSER

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Figure D-2-4

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	29.2	35.8	25.3	9.7	
▲	14.6	20.8	53.2	11.4	
■	13.4	25.5	44.2	16.9	

	LL	PI	D ₈₅	D ₆₀	D ₅₀	D ₃₀	D ₁₅	D ₁₀	C _c	C _u
●			211.35	24.83	12.74	2.851	0.2291	0.0794	4.12	312.6
▲			73.28	3.43	1.76	0.398	0.1496			
■			63.83	4.17	1.12	0.237				

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● Slightly silty, sandy GRAVEL with cobbles	GP-GM	27%
▲ Slightly silty, gravelly SAND with cobbles	SP-SM	46%
■ Silty, gravelly SAND with cobbles	SM	41%

Remarks:

Project: Blair Backup

● Location: TP-611, Depth: 0'-6'

▲ Location: TP-612, GS-1, Depth: 0.0'-7.5'

■ Location: TP-614, GS-1, Depth: 0'-9.5'

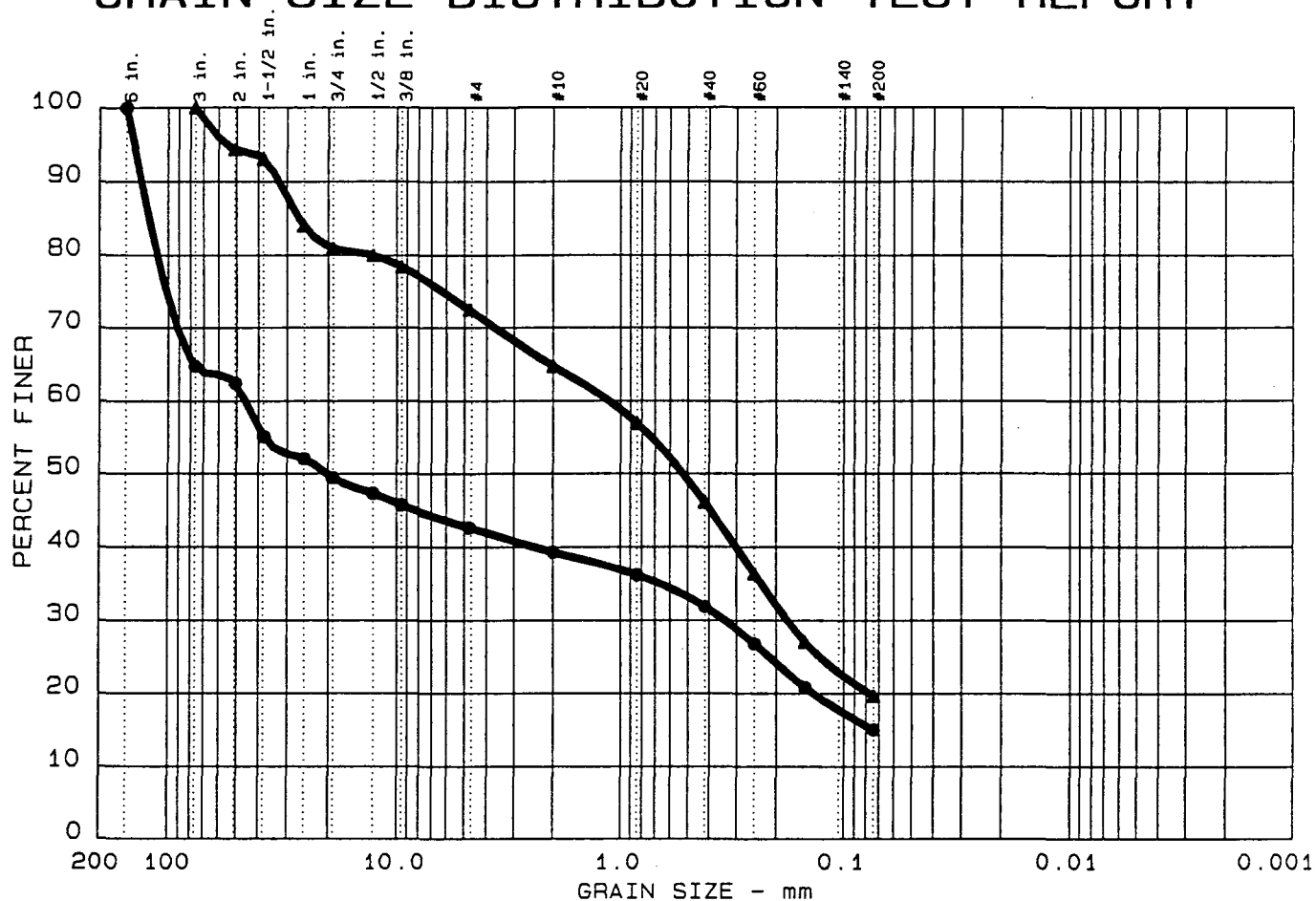


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Figure D-2-5

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75 mm	% GRAVEL	% SAND	% SILT	% CLAY
●	35.2	22.1	27.6	15.1	
▲	0.0	27.6	52.8	19.6	

	LL	PI	D ₈₅	D ₆₀	D ₅₀	D ₃₀	D ₁₅	D ₁₀	C _c	C _u
●			121.48	45.55	20.11	0.338				
▲			26.61	1.12	0.52	0.178				

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● Silty, sandy GRAVEL (cobbles)	GM	43%
▲ Silty, gravelly SAND	SM	40%

Remarks:

Project: Blair Backup

● Location: TP-618, G-1, Depth: 1'-5'

▲ Location: TP-619, G-1, Depth: 1'-5'



HART CROWSER

J-2350-20 5/6/92

Figure D-2-6

Hart Crowser
J-2350-20

APPENDIX E
PAH-CONTAMINATED MATERIAL

APPENDIX E

PAH-CONTAMINATED MATERIAL

Introduction

Between December 1989 and June 1992, soil and groundwater conditions were investigated at the Port of Tacoma's Blair Backup property. Test pits, surface soil sampling, and borings revealed the presence of polynuclear aromatic hydrocarbons (PAHs) materials in charcoal briquettes and the surrounding soil in concentrations which exceed allowable limits. This appendix describes the sampling activities, conditions encountered during excavation, and the results of analyses of samples obtained during excavation. Field exploration methods are discussed in Attachment E-1 while Attachment E-2 presents exploration logs. Attachment E-3 presented in Volume II presents Certificate of Analysis from Laucks Testing Laboratories, Inc. for materials analyzed for PAHs.

Site Background/Conditions

General site background information is contained in Section 2.0 with more specific information on the area impacted by PAHs contained in Section 2.2.3.1. This area is outlined on Figure E-1.

The surface of this area is largely devoid of vegetation. Much of the area is covered by relatively small amounts of wood debris probably resulting from previous use of the property for log sorting and storage. In addition, areas not covered by wood debris are generally covered with a mixture of dark brown, soil, quartz, and/or slag.

Subsurface conditions encountered during excavations varied greatly. In general, the top one to two feet consisted of a loose mixture of sand and wood chips over very gravelly sand. This was not consistent, however. Some excavations encountered very dense layers of consolidated slag 1 to 2 feet below the surface and construction debris was common. In most excavations, groundwater was encountered at a depth of 6 feet although some encountered water at depths of 2 feet and some encountered no water. A summary of the test excavations and the subsurface conditions where cPAH-contaminated soils were encountered is contained in Table E-1.

Sampling History

Site investigations at the Blair Backup property commenced with the Phase I assessment in 1989 and continued through the 700 series test pits, excavated in June

1992, accomplished to obtain a detailed assessment of the extent of both the charcoal briquette area and the surrounding PAH-impacted soil. Logs for borings and test pits excavated in the vicinity of the area of concern are presented in Attachment E-2.

A brief chronology of sampling events and a discussion of objectives for the 7 phases of test pit excavations completed in the OFA/Pennwalt Area include:

- ▶ **TP-100 through TP-200.** These test pits were excavated during the Phase I site assessment in December 1989 and September 1990. Samples were taken from TP-124, TP-200, TP-201, TP-205, TP-206, TP-207, and TP-210 for chemical analyses. Test pits TP-124, TP-207, TP-208, and TP-210 contained charcoal briquettes or noticeable fragments of charcoal briquettes.
- ▶ **TP-300.** The 300 series test pits were excavated in August 1991 to further delineate the extent of the charcoal material area. None of the 14 test pits were sampled for PAH analysis as the purpose of the excavations was a physical examination of the subsurface soils. Charcoal briquettes were observed in test pits TP-308 and TP-312.
- ▶ **TP-400.** The 400 series test pits were excavated in December 1991 to further establish the extent of PAH-contaminated soil. Test pits TP-400, TP-401, and TP-404 were sampled for PAHs; test pit TP-405 contained charcoal briquettes.
- ▶ **TP-500.** The 500 series test pits were excavated in February 1992. The purpose of the excavation was to obtain further information on the extent of PAH contamination and to establish PAH concentrations in the soil, consequently samples for chemical analysis were obtained from all 10 test pits. Charcoal briquettes were not encountered in any of these test pits.
- ▶ **TP-600.** The 600 series test pits were excavated in April 1992 as part of an additional effort to establish the extent of slag material within the area. Three of the 20 test pits excavated in this series (TP-600, TP-601, and TP-602) were sampled and analyzed to characterize the briquettes and the impacted soil according to Washington State Waste Designation criteria. Test pit TP-601 contained charcoal briquettes. Certificates of analysis for these samples are contained in Attachment E-3 presented in Volume II.
- ▶ **TP-700.** The 700 series test pits were excavated in June 1992. The purpose of the excavation was to delineate the areas of charcoal and PAH-containing soils, consequently all pits were sampled for chemical analysis. Test pits TP-702,

TP-707, TP-710, and TP-714 contained charcoal. Certificates of analysis for the 700 series test pits are contained in Attachment E-3 presented in Volume II.

Site Characterization

The results of the sampling and analysis indicate three general areas; the majority of the soil in the area which is below the 20 mg/kg PAH concentration MTCA cleanup criteria, the intermediate level soils greater than 20 mg/kg PAHs, and the charcoal briquettes. The unimpacted soils are obviously not of concern. The other two areas are characterized below.

Charcoal Briquettes

The charcoal briquette-laden soil was found in test pits TP-124, TP-207, TP-208, TP-210, TP-308, TP-312, TP-405, TP-601, TP-702, TP-707, TP-710, and TP-714. Logs of these test pits indicate the soil contains charcoal briquettes mixed with native soils and concrete and wood debris. The charcoal briquettes occur in a lens which extends from near the surface to depths of about 6 feet below the ground surface. The estimated extent of the charcoal materials is shown on Figure E-1. The results of our explorations indicate there are about 4,100 cy of charcoal briquette-laden soil in this area of the property.

Chemical analyses were performed on a discrete number of samples of charcoal briquette-laden soil and briquettes. The results of the analyses show the concentrations of total cPAH in soil samples ranged from 68.37 to 2,980 mg/kg. Results of analyses on the charcoal briquettes show the total cPAH concentrations to range from 1,835 to 9,370 mg/kg. All of the analytical results for the charcoal briquette-laden soil and the briquettes exceed both the Washington State MTCA Method A industrial soil cleanup level of 20 mg/kg. The above data were used to establish the general soil quality of all charcoal briquette-laden soil and briquettes on the site. Results of chemical analyses of samples of briquettes are contained in Table E-2; certificates of analysis are contained in Attachment E-3, presented in Volume II.

PAH-Contaminated Soil

Specific samples of site soil were analyzed for total metals, volatile organic compounds, semivolatile organic compounds, and petroleum hydrocarbons. Results of the analyses showed the total cPAH concentration ranged from 0.13 to 5,180 mg/kg. A summary of test results for all boring subsurface soil samples, surface soil samples, and test pit soil samples in the vicinity of the area of concern are included

in Tables E-3 through E-5, respectively. The laboratory certificates of analyses for these samples are presented in Attachment E-3, presented in Volume II. Explorations indicated that the presence of construction debris and a petrochemical-like odor were characteristic of this soil. Although the petrochemical odor suggests a contaminant source other than charcoal, chemical analysis indicates only the presence of PAHs, no recognizable petroleum product patterns were detected.

PAHs were identified in 59 soil samples analyzed from test pits, surface soil, and borings as tabularized in Table E-1. Nineteen samples contained concentrations of cPAHs in excess of the MTCA Method A industrial soil cleanup criteria of 20 mg/kg. Figure E-1 presents the estimated extent of soils containing cPAH concentrations of greater than 20 mg/kg. Based on these findings, we estimate there are about 8,900 to 9,300 cubic yards of soil containing PAHs in excess of the MTCA Method A cleanup criteria.

Volume Calculations. The estimated volumes included in the characterization of the charcoal briquette and PAH-contaminated areas were calculated as follows:

- ▶ The lateral extent of the contamination, as depicted on Figure E-1, was used to calculate the impacted surface area by taking direct measurements.
- ▶ The extent of vertical contamination was estimated by referring to the test pit logs to determine the sampling depth for samples falling within the various contours.
- ▶ The area of contamination was then multiplied by the estimated depth of contamination to calculate the volume of impacted soil in a given area.

Table E-1 - Summary of Charcoal and cPAH-Contaminated Soil Explorations and Testing

Sheet 1 of 5

Exploration/ Sample No.	Depth in Feet	cPAH Conc. in mg/kg	Soil Description
SS-102	0 - 0.5	1.7	
SS-104	0 - 0.5	42.8	
TP-124/S-1	1.5 - 2.5	237.9	Moist to wet, black, very gravelly SAND with wood debris, charcoal briquettes, and cobbles. Petrochemical-like odor.
TP-200/S-1	0.5 - 2.0	13.6	(Very dense), moist, very gravelly, fine to medium SAND with wood chips, wood fragments, river rock cobbles, and pink OFA slag. Petrochemical-like odor.
TP-201/S-1	1.0 - 2.0	1.5	(Very dense), moist, blackish-gray, very gravelly to gravelly SAND with large concrete blocks, wire, and silver, metallic OFA slag.
TP-205/S-2	4.5 - 5.0	18.0	Moist to wet, light gray, gravelly, coarse SAND (mainly quartz and black coal fragments). Petrochemical-like odor.
TP-206/S-1	2.0 - 3.0	46.0	Moist to wet, grayish black, gravelly SAND with Asarco and pink OFA slag.
TP-207/S-1	1.5 - 2.5	1,853.2 8,930.0 (Repl)	Moist, grayish black, gravelly SAND with abundant coal fragments, wood debris, charcoal briquettes, and some OFA slag and quartz. Petrochemical-like odor.
TP-210/S-1	2.5 - 3.5	6.5 (8270) 8.0 (8310) Avg. = 7.3	3 inches of (loose), moist, dark brown, gravelly SAND with wood chips and scattered pieces of slag, quartz, and coal over (dense), moist to wet, brown, gravelly, fine to medium SAND with metal (pipes, cables, wires, and sheets), and wood debris (railroad ties and timbers). Strong petrochemical-like odor.
TP-400/S-1	2.5 - 3.5	6.5	3 inches of (loose), moist, gravelly SAND with wood chips over wet brown, gravelly SAND.

Table E-1 - Summary of Charcoal and cPAH-Contaminated Soil Explorations and Testing

Sheet 2 of 5

Exploration/ Sample No.	Depth in Feet	cPAH Conc. in mg/kg	Soil Description
TP-401/S-1	4.0 - 5.0	183.8 (8270) 128.3 (8310) Avg. = 156.1	(Medium dense), moist to wet, gravelly SAND with decaying organic matter, quartz, and asphalt debris.
TP-404/S-1	2.0 - 3.0	28.5 (8270) 32.3 (8310) Avg. = 30.4	(Medium dense to loose), moist to wet, dark gray, gravelly SAND (multicolored grains) with metal (wires and cables), concrete, and wood debris (boards). Petrochemical-like odor.
TP-500/S-1	0.5 - 1.5	0.2	6 inches of (medium dense), wet, tan, silty, sandy GRAVEL over (dense), moist, green gray, silty, sandy GRAVEL (fill) with some wood fragments.
TP-500/S-2	3.0 - 4.0	14.4	(Medium stiff), wet, dark green gray, silty CLAY.
TP-501/S-1	0.5 - 1.5	0.1	6 inches of (medium dense), wet, tan, silty, sandy GRAVEL over (dense), moist, green gray, silty, sandy GRAVEL (fill) with some wood fragments.
TP-501/S-2	3.0 - 4.0	12.6	(Medium stiff), wet, dark green gray, silty CLAY.
TP-502/S-1	0.5 - 1.5	1,317	(Medium dense) brown, silty, sandy GRAVEL with some bricks and steel cables.
TP-502/S-2	2.5 - 3.5	1.0	(Medium dense), wet silty, sandy GRAVEL with pebbles.
TP-503/S-1	0.5 - 1.5	10.4	(Medium dense), damp, brown, silty, sandy GRAVEL with old wire, glass, and wood debris (fill).
TP-503/S-2	8.0 - 9.0	0.4	(Very dense), damp, green gray, silty, sandy GRAVEL with cobbles (fill).
TP-504/S-1	0.5 - 1.5	0.4	(Medium dense), wet, yellow brown, sandy GRAVEL mixed with chunks of asphalt.

Table E-1 - Summary of Charcoal and cPAH-Contaminated Soil Explorations and Testing

Sheet 3 of 5

Exploration/ Sample No.	Depth in Feet	cPAH Conc. in mg/kg	Soil Description
TP-504/S-2	2.5 - 3.5	4.5	(Medium dense), wet, dark gray, slightly gravelly, very silty SAND with bricks and wood debris (fill).
TP-505/S-1	0.5 - 1.5	11.8	6 inches of (medium dense), moist, dark brown, silty, sandy GRAVEL over (medium dense), moist, yellow brown, silty, sandy GRAVEL with some organics (wood). Asphalt chunks up to 1 foot in size.
TP-505/S-2	2.5 - 3.5	1.6	(Medium dense), wet, dark brown, silty, gravelly SAND. Approximately 80% of this zone is wood.
TP-506/S-1	0.5 - 1.5	0.4	(Medium dense), moist, brown, silty, gravelly SAND with abundant wood organics and lenses of (medium stiff), moist, gray, silty CLAY.
TP-506/S-2	3.0 - 4.0	0.4	(Medium dense), wet, dark gray, silty, gravelly SAND with abundant wood. Petrochemical-like odor.
TP-507/S-1 TP-507/S-2	0.5 - 1.5 2.5 - 3.5	1.6 1.2	(Medium dense), damp, brown, silty, sandy GRAVEL with abundant asphalt, steel wires, a large utility pole section, and several pieces of rebar from depths of 3 to 3½ feet.
TP-508/S-1	0.5 - 1.5	44.9	6 inches of (loose), wet, dark brown, silty, sandy GRAVEL over (medium dense), moist, yellow brown, sandy GRAVEL with abundant wood, organics, 1½ inch pipe, and some asphalt.
TP-508/S-2	2.5 - 3.5	2,980	(Medium dense), moist to wet, dark brown, silty, sandy GRAVEL with cobbles and abundant wood fragments.
TP-509/S-1	0.5 - 1.5	2.7	(Medium dense), moist, dark grayish brown, silty, sandy GRAVEL with some organics (wood).
TP-509/S-2	2.5 - 3.5	85.8	Silty, gravelly SAND with pockets of quartz.

Table E-1 - Summary of Charcoal and cPAH-Contaminated Soil Explorations and Testing

Sheet 4 of 5

Exploration/ Sample No.	Depth in Feet	cPAH Conc. in mg/kg	Soil Description
TP-600/S-1	1.0 - 2.0	2.0	(Loose), wet dark brown, silty, sandy GRAVEL, with logs, strong odor, some cobbles, asphalt, wire.
TP-601/S-1	0.0 - 3.0	8,620	Charcoal briquette in (soft), moist, black, gravelly SILT matrix with wood debris.
TP-602/S-1	0.0 - 4.0	286.0	(Loose), wet, gray brown, sandy SILT.
TP-701/S-1	1.0 - 2.5	3.1	(Very dense), dark brown, silty, sandy GRAVEL with wood debris.
TP-702/S-1	0.5 - 1.5	5,180	Crushed rock over black charcoal layer.
TP-702/S-2	2.0 - 3.0	9.1	(Loose), dark brown, slightly silty SAND.
TP-703/S-1	1.0 - 2.0	2.3	(Loose), moist, dark brown, silty SAND.
TP-703/S-2	3.5 - 4.5	0.2	(Very loose), wet, dark brown, silty SAND.
TP-704/S-1	1.0 - 2.0	0.5	(Very dense), brown to blue-gray TILL.
TP-704/S-2	3.5 - 4.5	3.6	Moist, dark brown wood debris and wood shavings.
TP-705/S-1	1.0 - 2.0	3.6	(Dense), brownish-gray, silty SAND gravels.
TP-705/S-2	3.0 - 4.0	58.3	(Loose), dark gray, moist, slightly silty SAND.
TP-706/S-1	1.0 - 2.0	2.2	(Medium dense), brown, slightly silty, sandy GRAVEL with organics (grass, roots, etc.)
TP-707/S-1	1.5 - 2.5	1.3	(Dense), dark brown, silty, sandy GRAVEL.
TP-707/S-2	4.5 - 5.5	802	Charcoal briquettes, black, shiny, tar-like, with wrapped wire debris.
TP-708/S-1	0.5 - 1.5	4.9	(Dense), damp, black, sandy, very silty GRAVEL with wood debris.

Table E-1 - Summary of Charcoal and cPAH-Contaminated Soil Explorations and Testing

Sheet 5 of 5

Exploration/ Sample No.	Depth in Feet	cPAH Conc. in mg/kg	Soil Description
TP-708/S-2	2.5 - 3.5	68.5	(Very dense), wet, gray to black, silty, sandy GRAVEL with wood debris.
TP-709/S-1	1.5 - 2.5	3.4	Damp, black, silty, sandy GRAVEL with plastic bag debris.
TP-709/S-2	4.0 - 5.0	1.5	(Very dense), moist to wet, dark gray to black, silty, sandy GRAVEL with wood debris.
TP-710/S-1	0.5 - 1.5	251	(Dense), moist, black, sandy, very silty GRAVEL with charcoal debris.
TP-711/S-1	1.0 - 2.0	1.7	Damp, dark brown wood debris.
TP-711/S-2	3.0 - 4.0	1.4	Moist to wet, black, slag, silty, sandy GRAVEL.
TP-712/S-1	1.5 - 2.5	3.2	Dark brown wood debris with silts, sands, and gravels and wire rope.
TP-712/S-2	3.5 - 4.5	2.2	(Very dense), dark gray to black, silty, sandy GRAVEL with slag pockets.
TP-713/S-1	1.5 - 2.5	1.7	(Dense), damp, dark brown, very silty, sandy GRAVEL with organics.
TP-713/S-2	3.5 - 4.5	2.2	(Medium dense), moist, dark gray to black, gravelly, sandy silts with wood chips.
TP-714/S-1	1.0 - 2.0	74.4	(Dense), damp, brown, silty, sandy GRAVEL with wood debris.
TP-714/S-2	3.0 - 4.0	2,028	Moist black, silty, sandy GRAVEL with wood debris, concrete, telephone cable, rebar, and charcoal briquettes.

Table E-2 - Analytical Results for Charcoal Samples

Sample Number	Coke/TP-124	Charcoal	Charcoal	Charcoal	Charcoal
Date Sampled	Sept 1990 (b)	Sept 1990	Sept 1990(b)	Jan 1991(b)	Jan 1991
Sample Depth in Feet	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5
EPA Replicate		EPA Replicate			
Total Metals	NA	NA	NA	NA	NA
in mg/kg (ppm)	NA	NA	NA	NA	NA
Arsenic	NA	NA	NA	NA	NA
Cadmium	NA	NA	NA	NA	NA
Chromium	NA	NA	NA	NA	NA
Copper	NA	NA	NA	NA	NA
Lead	NA	NA	NA	NA	NA
Manganese	NA	NA	NA	NA	NA
Mercury	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	NA
Selenium	NA	NA	NA	NA	NA
Silver	NA	NA	NA	NA	NA
Zinc	NA	NA	NA	NA	NA
EP Toxicity Metals					
in mg/L (ppm)					
Arsenic	NA	NA	NA	NA	NA
Barium	NA	NA	NA	NA	NA
Cadmium	NA	NA	NA	NA	NA
Chromium	NA	NA	NA	NA	NA
Copper	NA	NA	NA	NA	NA
Lead	NA	NA	NA	NA	NA
Mercury	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	NA
Zinc	NA	NA	NA	NA	NA
TCLP Metals					
in mg/L (ppm)					
Arsenic	NA	NA	NA	NA	NA
Barium	NA	NA	NA	NA	NA
Cadmium	NA	NA	NA	NA	NA
Chromium	NA	NA	NA	NA	NA
Copper	NA	NA	NA	NA	NA
Lead	NA	NA	NA	NA	NA
Mercury	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	NA
Selenium	NA	NA	NA	NA	NA
Silver	NA	NA	NA	NA	NA
Zinc	NA	NA	NA	NA	NA

Table E-2 - Analytical Results for Charcoal Samples

Sample Number	Coke/TP-124	Charcoal	Charcoal	Charcoal	Charcoal
Date Sampled	Sept 1990 (b)	Sept 1990	Sept 1990(b)	Jan 1991(b)	Jan 1991
Sample Depth in Feet	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5
	EPA Replicate		EPA Replicate		
Volatile Organic Compounds					
in mg/kg (ppm)					
Vinyl Chloride	NA	NA	NA	NA	NA
Acetone	NA	NA	NA	NA	NA
Carbon disulfide	NA	NA	NA	NA	NA
trans-1,2-Dichloroethene	NA	NA	NA	NA	NA
cis-1,2-Dichloroethene	NA	NA	NA	NA	NA
Total 1,2-Dichloroethene	NA	NA	NA	NA	NA
2-Butanone (MEK)	NA	NA	NA	NA	NA
1,2-Dichloroethane	NA	NA	NA	NA	NA
Trichloroethene	NA	NA	NA	NA	NA
Benzene	NA	NA	NA	NA	NA
Toluene	NA	NA	NA	NA	NA
Ethylbenzene	NA	NA	NA	NA	NA
Total Xylenes	NA	NA	NA	NA	NA
Semivolatile Organic Compounds					
in mg/kg (ppm)					
Napthalene	20 U	63	1,600	200 J	250 UJ
2-Methylnapthalene	20 U	NA	830	160 J	NA
Acenaphthylene	20 U	270	1,700	1,200	680 J
Acenaphthene	20 U	50 U	940	260	880 J
Dibenzofuran	20 U	NA	200 J	NA	NA
Fluorene	20 U	150	1,400	860	980 J
Phenanthrene	2.7 J	1,100	6,700	6,700	5,600 J
Anthracene	20 U	220 B	1,700	1,500	1,000 J
Fluoranthene	20 U	1,200	3,200	4,200	4,100 J
Pyrene	1.5 J	760	3,600	4,300	4,100 J
Benzo(a)anthracene	20 U	360	1,600	1,200	850 J
Chrysene	20 U	400	2,100	1,400	900 J
Bis(2-ethylhexyl)phthalate	3.9 J	NA	250 U	NA	NA
Di-n-octyl phthalate	20 U	NA	250 U	NA	NA
Benzo(b)fluoranthene	20 U	210	1,400	1,500	490 J
Benzo(k)fluoranthene	20 U	120	970	540	260 J
Benzo(a)pyrene	20 U	500	1,600	1,700	940 J
Indeno(1,2,3-cd)pyrene	20 U	240	1,500	1,100	490 J
Dibenzo(a,h)anthracene	20 U	10 J	200 J	260 U	100 UJ
Benzo(g,h,i)perylene	20 U	210	310	1,400	460 J

Table E-2 - Analytical Results for Charcoal Samples

Sample Number	Coke/TP-124	Charcoal	Charcoal	Charcoal	Charcoal
Date Sampled	Sept 1990 (b)	Sept 1990	Sept 1990(b)	Jan 1991(b)	Jan 1991
Sample Depth in Feet	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5
EPA Replicate		EPA Replicate			
TCLP Polynuclear Aromatic					
Hydrocarbons in mg/L (ppm)					
Napthalene	NA	NA	NA	NA	NA
Acenaphthylene	NA	NA	NA	NA	NA
Acenaphthene	NA	NA	NA	NA	NA
Fluorene	NA	NA	NA	NA	NA
Phenanthrene	NA	NA	NA	NA	NA
Anthracene	NA	NA	NA	NA	NA
Fluoranthene	NA	NA	NA	NA	NA
Pyrene	NA	NA	NA	NA	NA
Benzo(a)anthracene	NA	NA	NA	NA	NA
Chrysene	NA	NA	NA	NA	NA
Benzo(b)fluoranthene	NA	NA	NA	NA	NA
Benzo(k)fluoranthene	NA	NA	NA	NA	NA
Benzo(a)pyrene	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	NA	NA	NA	NA	NA
Benzo(g,h,i)perylene	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	NA	NA	NA	NA	NA
Miscellaneous Parameters					
in mg/kg (ppm)					
GC-FID Screen	NA	NA	NA	NA	NA
GC-FID Screen 8015 Modified	NA	18,000 J	NA	NA	8,100
GC-FID Screen 8015 Modified (a)	NA	18,000 J	NA	NA	NA
TPH (418.1)	NA	NA	NA	NA	690
Organophosphorous Pesticides	NA	NA	NA	NA	NA
Chlorinated Herbicides	NA	NA	NA	NA	NA
Pesticides/PCBs					
in mg/kg (ppm)					
4,4'-DDE	NA	NA	NA	NA	NA
4,4'-DDD	NA	NA	NA	NA	NA
4,4'-DDT	NA	NA	NA	NA	NA

Notes:

U - Indicates compound was analyzed for but not detected at the given detection limit.

B - Indicates analyte was detected in laboratory method blank.

J - Indicates an estimated value.

NA - Not analyzed.

(a) - Total cPAHs were calculated using one-half the detection limit values for non-detected results.

Table E-3 - Analytical Results from Boring Subsurface Soil Samples

Boring/Sample Number	HC-4S/S-1	HC-4S/S-2	HC-11S/S-1
Date Sampled	Dec 1989	Dec 1989	Dec 1989
Sample Depth in Feet	2.5-4.0	5.0-6.5	2.5-4.0
Total Metals in mg/kg			
Arsenic	0.8	2.1	3
Cadmium	0.5 U	0.5 U	0.5 U
Chromium	22	14	3000
Copper	20	13	11
Lead	10 U	10 U	10 U
Manganese	NA	NA	NA
Mercury	0.1 U	0.1 U	0.1 U
Nickel	13	8	31
Selenium	NA	NA	NA
Silver	NA	NA	NA
Zinc	32	22	13
EP Toxicity Metals in mg/L			
Arsenic	NA	NA	0.2 UJ
Barium	NA	NA	0.2
Cadmium	NA	NA	0.01 U
Chromium	NA	NA	0.1 UJ
Copper	NA	NA	0.1 UJ
Lead	NA	NA	0.1 UJ
Mercury	NA	NA	0.005 U
Nickel	NA	NA	0.2
Zinc	NA	NA	0.1 J
Volatile Organic Compounds in mg/kg			
Vinyl chloride	NA	0.002 U	NA
Acetone	NA	0.062 U	NA
Carbon disulfide	NA	0.002 U	NA
trans-1,2-Dichloroethene	NA	0.002 U	NA
cis-1,2-Dichloroethene	NA	0.002 U	NA
Total 1,2-Dichloroethene	NA	0.002 U	NA
2-Butanone (MEK)	NA	0.005 U	NA
1,2-Dichloroethane	NA	0.002 U	NA
Trichloroethene	NA	0.002 U	NA
Benzene	NA	0.002 U	NA
Toluene	NA	0.002 U	NA
Ethylbenzene	NA	0.002 U	NA
Total Xylenes	NA	0.005	NA

Table E-3 - Analytical Results from Boring Subsurface Soil Samples

Boring/Sample Number	HC-4S/S-1	HC-4S/S-2	HC-11S/S-1
Date Sampled	Dec 1989	Dec 1989	Dec 1989
Sample Depth in Feet	2.5-4.0	5.0-6.5	2.5-4.0
Miscellaneous Parameters in mg/kg			
GC-FID Screen	44	21	290
GC-FID Screen 8015 Modified	NA	NA	NA
GC-FID Screen 8015 Modified(a)	NA	NA	NA
TPH (418.1)	NA	NA	NA
Pesticides in mg/kg			
4,4'-DDE	0.02 U	0.02 U	NA
4,4'-DDD	0.02 U	0.02 U	NA
4,4'-DDT	0.02 U	0.02 U	NA

Notes:

U - Indicates compound was analyzed for but not detected at the given detection limit.

J - Indicates an estimated value.

(a) - After silica gel cleanup.

NA - Not analyzed.

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Table E-4 - Analytical Results from Surface Soil Samples

Sample Number	SS-2	SS-102	SS-103	SS-104
Date Sampled	Dec 1989	Sept 1990	Sept 1990	Sept 1990
Sample Depth in Feet	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5
Total Metals in mg/kg				
Arsenic	130	NA	NA	NA
Cadmium	1.3	NA	NA	NA
Chromium	110	NA	NA	NA
Copper	310	NA	NA	NA
Lead	130	NA	NA	NA
Manganese	NA	NA	NA	NA
Mercury	0.1 U	NA	NA	NA
Nickel	270	NA	NA	NA
Selenium	NA	NA	NA	NA
Silver	NA	NA	NA	NA
Zinc	310	NA	NA	NA
Semivolatile Organic Compounds in mg/kg				
Non-carcinogenic PAHs				
Napthalene	NA	0.13 U	NA	0.83 U
2-Methylnapthalene	NA	NA	NA	NA
Acenaphthylene	NA	0.26 U	NA	1.7 U
Acenaphthene	NA	0.26 U	NA	1.7 U
Benzo(g,h,i)perylene	NA	0.29	NA	6
Bis(2-ethylhexyl)phthalate	NA	NA	NA	NA
Di-n-octyl phthalate	NA	NA	NA	NA
Fluorene	NA	0.07	NA	1.5
Phenanthrene	NA	0.31	NA	4.5
Anthracene	NA	0.061	NA	1.5
Fluoranthene	NA	0.1	NA	0.17 U
Pyrene	NA	0.64	NA	24
Carcinogenic PAHs				
Benzo(a)anthracene	NA	0.27	NA	8.2
Chrysene	NA	0.41	NA	9.4
Benzo(b)fluoranthene	NA	0.27	NA	5.6
Benzo(k)fluoranthene	NA	0.12	NA	3
Benzo(a)pyrene	NA	0.33	NA	10
Ideno(1,2,3-cd)pyrene	NA	0.24	NA	6.4
Dibenzo(a,h)anthracene	NA	0.051 U	NA	0.34 U
Total cPAHs (a)	NA	1.67	NA	42.77
Other Semivolatiles				
Dibenzofuran	NA	NA	NA	NA
Miscellaneous Parameters in mg/kg				
GC-FID Screen	360 B	NA	NA	NA
GC-FID Screen 8015 Modified	NA	300 J	300 J	500 J
GC-FID Screen 8015 Modified(b)	NA	200 J	NA	300 J
TPH (418.1)	NA	620 J	NA	1500 J

Notes:

U - Indicates compound was analyzed for but not detected at the given detection limit.

J - Indicates an estimated value.

(a) - Total cPAHs were calculated using one-half the detection limit values for non-detected results.

(b) - After silica gel cleanup.

NA - Not analyzed.

Table E-5 - Analytical Results from Test Pit Soil Samples

Test Pit/Sample Number	TP124/S-1	TP125/S-2	TP127/S-1	TP128/S-1	TP134/S-1
Date Sampled	Dec 1989	Dec 1989	Dec 1989	Dec 1989	Dec 1989
Sample Depth in Feet	1.5-2.5	4.0-5.0	1.5-2.5	3.0-4.0	2.0-3.0
Total Metals in mg/kg					
Arsenic	26 J	49	21	88	37
Cadmium	1.3	2.6	1.2	4.5	0.93
Chromium	22 B	47 B	91 B	100 B	1100 B
Copper	99	1500	300	240	170
Lead	84	1100	74	130	59
Manganese	NA	NA	NA	NA	NA
Mercury	0.1 U	0.6	0.1 U	0.1	0.1 U
Nickel	12	35	43	20	77
Selenium	NA	NA	NA	NA	NA
Silver	NA	NA	NA	NA	NA
Zinc	97 B	380 B	140 B	270 B	210 B
EP Toxicity Metals in mg/L					
Arsenic	NA	0.2 UJ	NA	NA	0.2 UJ
Barium	NA	0.3	NA	NA	0.2
Cadmium	NA	0.01 U	NA	NA	0.01 U
Chromium	NA	0.1 UJ	NA	NA	0.1 UJ
Copper	NA	0.4 J	NA	NA	0.1 UJ
Lead	NA	0.1 UJ	NA	NA	0.1 UJ
Mercury	NA	0.005 U	NA	NA	0.005 U
Nickel	NA	0.1 U	NA	NA	0.1 U
Zinc	NA	0.3 J	NA	NA	0.2 J
Volatile Organic Compounds in mg/kg					
Vinyl chloride	0.002 UJ	NA	NA	NA	0.002 U
Acetone	0.032 UJ	NA	NA	NA	0.024 U
Carbon disulfide	0.002 UJ	NA	NA	NA	0.002 U
trans-1,2-Dichloroethene	0.002 UJ	NA	NA	NA	0.002 U
cis-1,2-Dichloroethene	0.002 UJ	NA	NA	NA	0.002 U
Total 1,2-Dichloroethene	0.002 UJ	NA	NA	NA	0.002 U
2-Butanone (MEK)	0.006 UJ	NA	NA	NA	0.006 U
1,2-Dichloroethane	0.002 UJ	NA	NA	NA	0.002 U
Trichloroethene	0.002 UJ	NA	NA	NA	0.002 U
Benzene	0.002 UJ	NA	NA	NA	0.002 U
Toluene	0.002 UJ	NA	NA	NA	0.002 U
Ethylbenzene	0.002 UJ	NA	NA	NA	0.002 U
Total Xylenes	0.002 UJ	NA	NA	NA	0.002 U

Table E-5 - Analytical Results from Test Pit Soil Samples

Test Pit/Sample Number	TP124/S-1	TP125/S-2	TP127/S-1	TP128/S-1	TP134/S-1
Date Sampled	Dec 1989	Dec 1989	Dec 1989	Dec 1989	Dec 1989
Sample Depth in Feet	1.5-2.5	4.0-5.0	1.5-2.5	3.0-4.0	2.0-3.0
Semivolatile Organic Compounds in mg/kg					
Non-carcinogenic PAHs					
Napthalene	7.6	NA	NA	NA	NA
2-Methylnapthalene	3.9	NA	NA	NA	NA
Acenaphthylene	12	NA	NA	NA	NA
Acenaphthene	12	NA	NA	NA	NA
Benzo(g,h,i)perylene	37 D	NA	NA	NA	NA
Bis(2-ethylhexyl)phthalate	0.19 UB	NA	NA	NA	NA
Di-n-octyl phthalate	0.17 U	NA	NA	NA	NA
Fluorene	15	NA	NA	NA	NA
Phenanthrene	120 D	NA	NA	NA	NA
Anthracene	32 D	NA	NA	NA	NA
Fluoranthene	120 D	NA	NA	NA	NA
Pyrene	130 D	NA	NA	NA	NA
Carcinogenic PAHs					
Benzo(a)anthracene	39 D	NA	NA	NA	NA
Chrysene	43 D	NA	NA	NA	NA
Benzo(b)fluoranthene	73 TD	NA	NA	NA	NA
Benzo(k)fluoranthene	73 TD	NA	NA	NA	NA
Benzo(a)pyrene	47 D	NA	NA	NA	NA
Ideno(1,2,3-cd)pyrene	31 D	NA	NA	NA	NA
Dibenzo(a,h)anthracene	4.9 D	NA	NA	NA	NA
Total cPAHs (a)	237.9	NA	NA	NA	NA
Other Semivolatiles					
Dibenzofuran	1.6	NA	NA	NA	NA
Miscellaneous Parameters in mg/kg					
GC-FID Screen	1200	110	33	930	23
GC-FID Screen 8015 Modified	NA	NA	NA	NA	NA
GC-FID Screen 8015 Modified(b)	NA	NA	NA	NA	NA
TPH (418.1)	NA	NA	NA	NA	NA

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Table E-5 - Analytical Results from Test Pit Soil Samples (Continued)

Test Pit/Sample Number	TP205/S-1	TP205/S-2	TP206/S-1	TP207/S-1	TP 207
Date Sampled	Sept 1990	Sept 1990	Sept 1990	Sept 1990	Sept 1990
Sample Depth in Feet	2.0-3.0	4.5-5.0	2.0-3.0	1.5-2.5	1.5-2.5
					EPA Replicate
Total Metals in mg/kg					
Arsenic	NA	NA	NA	NA	NA
Cadmium	NA	NA	NA	NA	NA
Chromium	NA	NA	NA	NA	NA
Copper	NA	NA	NA	NA	NA
Lead	NA	NA	NA	NA	NA
Manganese	NA	NA	NA	NA	NA
Mercury	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	NA
Selenium	NA	NA	NA	NA	NA
Silver	NA	NA	NA	NA	NA
Zinc	NA	NA	NA	NA	NA
Semivolatile Organic Compounds in mg/kg					
Non-carcinogenic PAHs					
Napthalene	NA	0.83 U	0.83 U	89 J	710
2-Methylnapthalene	NA	NA	NA	NA	370
Acenaphthylene	NA	1.7 U	1.7 U	280 J	410
Acenaphthene	NA	1.7 U	1.7 U	21 U	1300
Benzo(g,h,i)perylene	NA	3.8	10	240 J	280
Bis(2-ethylhexyl)phthalate	NA	NA	NA	NA	240 U
Di-n-octyl phthalate	NA	NA	NA	NA	240 U
Fluorene	NA	1.3	1.5	940 J	970
Phenanthrene	NA	5.6	2.5	3300 J	3800
Anthracene	NA	0.92 B	0.66 B	770 J	1300
Fluoranthene	NA	9	0.17 U	2.1 U	3000
Pyrene	NA	5.1	12	2000 J	3300
Carcinogenic PAHs					
Benzo(a)anthracene	NA	2.7	7	570 J	1600
Chrysene	NA	3	7.9	2.1 U	1900
Benzo(b)fluoranthene	NA	2.5	6.2	250 J	1400
Benzo(k)fluoranthene	NA	1.3	4.2	170 J	850
Benzo(a)pyrene	NA	4.7	12	600 J	1500
Ideno(1,2,3-cd)pyrene	NA	3.6	8.5	260 J	1400
Dibenzo(a,h)anthracene	NA	0.34 U	0.34 U	4.2 U	280
Total cPAHs (a)	NA	17.97	45.97	1853.2	930
Other Semivolatiles					
Dibenzofuran	NA	NA	NA	NA	120 J

Table E-5 - Analytical Results from Test Pit Soil Samples (Continued)

Test Pit/Sample Number	TP205/S-1	TP205/S-2	TP206/S-1	TP207/S-1	TP 207
Date Sampled	Sept 1990	Sept 1990	Sept 1990	Sept 1990	Sept 1990
Sample Depth in Feet	2.0-3.0	4.5-5.0	2.0-3.0	1.5-2.5	1.5-2.5
TCLP Polynuclear Aromatic Hydrocarbons in mg/L					
Napthalene	NA	0.021 J	NA	0.51 J	NA
Acenaphthylene	NA	0.0023 J	NA	0.01 U	NA
Acenaphthene	NA	0.037 J	NA	0.19 J	NA
Fluorene	NA	0.013 J	NA	0.096 J	NA
Phenanthrene	NA	0.036 J	NA	0.16 J	NA
Anthracene	NA	0.0044 BJ	NA	0.019 B	NA
Fluoranthene	NA	0.0037 J	NA	0.019 J	NA
Pyrene	NA	0.0038 J	NA	0.019 J	NA
Benzo(a)anthracene	NA	0.0001 UJ	NA	0.001 U	NA
Chrysene	NA	0.0001 UJ	NA	0.001 U	NA
Benzo(b)fluoranthene	NA	0.0001 UJ	NA	0.001 U	EPA Replicate
Benzo(k)fluoranthene	NA	0.0001 UJ	NA	0.001 U	NA
Benzo(a)pyrene	NA	0.0001 UJ	NA	0.001 U	NA
Dibenzo(a,h)anthracene	NA	0.0002 UJ	NA	0.002 U	NA
Benzo(g,h,i)perylene	NA	0.0001 UJ	NA	0.001 U	NA
Indo(1,2,3-cd)pyrene	NA	0.0001 UJ	NA	0.001 U	NA
Miscellaneous Parameters in mg/kg					
GC-FID Screen	NA	NA	NA	NA	NA
GC-FID Screen 8015 Modified	400 J	100 J	100 J	9000 J	NA
GC-FID Screen 8015 Modified(500 J	NA	NA	7000 J	NA
TPH (418.1)	890 J	NA	240 J	600 J	NA

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Table E-5 - Analytical Results from Test Pit Soil Samples (Continued)

Test Pit/Sample Number	TP208/S-1	TP208/S-2	TP209/S-1	TP210/S-1
Date Sampled	Sept 1990	Sept 1990	Sept 1990	Sept 1990
Sample Depth in Feet	1.0-2.0	2.0-3.0	1.5-2.5	0.5-2.5
Total Metals in mg/kg				
Arsenic	NA	3.4	NA	NA
Cadmium	NA	0.5 U	NA	NA
Chromium	NA	1400	NA	NA
Copper	NA	3.4	NA	NA
Lead	NA	10 U	NA	NA
Manganese	NA	NA	NA	NA
Mercury	NA	0.1 U	NA	NA
Nickel	NA	8.6	NA	NA
Selenium	NA	NA	NA	NA
Silver	NA	NA	NA	NA
Zinc	NA	6.6	NA	NA
Semivolatile Organic Compounds in mg/kg				
Non-carcinogenic PAHs				
Napthalene	NA	NA	NA	0.83 U
2-Methylnapthalene	NA	NA	NA	NA
Acenapthylene	NA	NA	NA	1.7 U
Acenapthene	NA	NA	NA	1.7 U
Benzo(g,h,i)perylene	NA	NA	NA	9
Bis(2-ethylhexyl)phthalate	NA	NA	NA	NA
Di-n-octyl phthalate	NA	NA	NA	NA
Fluorene	NA	NA	NA	0.17 U
Phenanthrene	NA	NA	NA	6.8
Anthracene	NA	NA	NA	2.5 B
Fluoranthene	NA	NA	NA	0.17 U
Pyrene	NA	NA	NA	38
Carcinogenic PAHs				
Benzo(a)anthracene	NA	NA	NA	13
Chrysene	NA	NA	NA	14
Benzo(b)fluoranthene	NA	NA	NA	8.5
Benzo(k)fluoranthene	NA	NA	NA	4.7
Benzo(a)pyrene	NA	NA	NA	18
Ideno(1,2,3-cd)pyrene	NA	NA	NA	10
Dibenzo(a,h)anthracene	NA	NA	NA	0.34 U
Total cPAHs (a)	NA	NA	NA	68.37
Other Semivolatiles				
Dibenzofuran	NA	NA	NA	NA

Table E-5 - Analytical Results from Test Pit Soil Samples (Continued)

Test Pit/Sample Number	TP208/S-1	TP208/S-2	TP209/S-1	TP210/S-1
Date Sampled	Sept 1990	Sept 1990	Sept 1990	Sept 1990
Sample Depth in Feet	1.0-2.0	2.0-3.0	1.5-2.5	0.5-2.5
TCLP Polynuclear Aromatic Hydrocarbons in mg/L				
Napthalene	NA	NA	NA	0.0005 UJ
Acenaphthylene	NA	NA	NA	0.001 UJ
Acenaphthene	NA	NA	NA	0.001 UJ
Fluorene	NA	NA	NA	0.0001 UJ
Phenanthrene	NA	NA	NA	0.00016 J
Anthracene	NA	NA	NA	0.00012 BJ
Fluoranthene	NA	NA	NA	0.0001 UJ
Pyrene	NA	NA	NA	0.00018 J
Benzo(a)anthracene	NA	NA	NA	0.0001 UJ
Chrysene	NA	NA	NA	0.0001 UJ
Benzo(b)fluoranthene	NA	NA	NA	0.0001 UJ
Benzo(k)fluoranthene	NA	NA	NA	0.0001 UJ
Benzo(a)pyrene	NA	NA	NA	0.0001 UJ
Dibenzo(a,h)anthracene	NA	NA	NA	0.0002 UJ
Benzo(g,h,i)perylene	NA	NA	NA	0.0001 UJ
Indo(1,2,3-cd)pyrene	NA	NA	NA	0.0001 UJ
Miscellaneous Parameters in mg/kg				
GC-FID Screen	NA	NA	NA	NA
GC-FID Screen 8015 Modified	300 J	NA	3 J	100 J
GC-FID Screen 8015 Modified(b)	NA	NA	NA	200 J
TPH (418.1)	88 J	NA	NA	190 J

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Table E-5 - Analytical Results from Test Pit Soil Samples (Continued)

Test Pit/Sample Number	TP400/S-1	TP401/S-1	TP404/S-1
Date Sampled	Dec 1991	Dec 1991	Sept 1990
Sample Depth in Feet	2.5-3.5	4.0-5.0	2.0-3.0
Volatile Organic Compounds in mg/kg			
Methylene chloride	0.003	0.004	0.013
Acetone	0.021 UB	0.073 UB	0.27
2-Butanone (MEK)	0.005 U	0.014	0.048
Ethylbenzene	0.002 U	0.001 U	0.008
Total Xylenes	0.012	0.001 U	0.043
Semivolatile Organic Compounds in mg/kg (8270)			
Non-carcinogenic PAHs			
Naphthalene	2.5	2.2	20
2-Methylnaphthalene	1.6	1.3 U	10
Acenaphthylene	1.2 U	4.4	1.2 U
Acenaphthene	2.8	1.3 U	6.8
Benzo(g,h,i)perylene	1.3	43	5
Fluorene	2.4	1.3 U	5.4
Phenanthrene	7.3	9.2	15
Anthracene	1.6	3.9	2.6
Fluoranthene	4	39	11
Pyrene	3.2	60	12
Carcinogenic PAHs			
Benzo(a)anthracene	1.2 U	28	4.7
Chrysene	1.3	28	5.4
Benzo(b)fluoranthene	2 T	45 T	7.7 T
Benzo(k)fluoranthene	2 T	45 T	7.7 T
Benzo(a)pyrene	1.4	40	5.9
Ideno(1,2,3-cd)pyrene	1.2 U	35	4.2
Dibenzo(a,h)anthracene	1.2 U	7.8	1.2 U
Total cPAHs (a)	6.5	183.8	28.5
Other Semivolatiles			
Carbazole	6.1 U	0.91 J	1.7 J
Dibenzofuran	2.2	1.3 U	3.7

Table E-5 - Analytical Results from Test Pit Soil Samples (Continued)

Test Pit/Sample Number	TP400/S-1	TP401/S-1	TP404/S-1
Date Sampled	Dec 1991	Dec 1991	Sept 1990
Sample Depth in Feet	2.5-3.5	4.0-5.0	2.0-3.0
Polynuclear Aromatic Hydrocarbons in mg/kg (8310)			
Non-carcinogenic PAHs			
Naphthalene	5.6 JD	160 JUD	15 JD
Acenaphthylene	19 UD	200 JUD	190 JUD
Acenaphthene	15 UD	160 JUD	4.3 JD
Benzo(g,h,i)perylene	0.51 JD	16 JD	4.8 JD
Fluorene	5.1 D	2.2 JD	4.5 JD
Phenanthrene	15 JD	13 JD	13 JD
Anthracene	2.4 JD	3.1 JD	2.3 JD
Fluoranthene	6.4 JD	31 JD	8.6 JD
Pyrene	14 JD	67 JD	25 JD
Carcinogenic PAHs			
Benzo(a)anthracene	2.4 D	22 JD	6.7 JD
Chrysene	1.6 D	17 JD	5.2 JD
Benzo(b)fluoranthene	2.6 D	34 JD	9.1 JD
Benzo(k)fluoranthene	0.14 UD	14 JD	1.9 JD
Benzo(a)pyrene	0.7 D	23 JD	3.9 JD
Dibenzo(a,h)anthracene	0.25 UD	2.6 JUD	2.5 JUD
Ideno(1,2,3-cd)pyrene	0.51 D	17 JD	4.1 JD
Total cPAHs (a)	8.01	128.3 J	32.2 J
PCBs in mg/kg			
Aroclor-1016	0.041 U	0.043 UJ	0.041 UJ
Aroclor-1221	0.083 U	0.086 UJ	0.083 UJ
Aroclor-1232	0.041 U	0.043 UJ	0.041 UJ
Aroclor-1242	0.041 U	0.043 UJ	0.041 UJ
Aroclor-1248	0.041 U	0.043 UJ	0.041 UJ
Aroclor-1254	0.041 U	0.043 UJ	0.041 UJ
Aroclor-1260	0.077	0.14 J	0.2 J

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Table E-5 - Analytical Results from Test Pit Soil Samples (Continued)

Test Pit/Sample Number	TP500/S-1	TP500/S-2	TP501/S-1	TP501/S-2
Date Sampled	Feb 1992	Feb 1992	Feb 1992	Feb 1992
Sample Depth in Feet	0.5-1.5	3.0-4.0	0.5-1.5	3.0-4.0
Semivolatile Organic Compounds in mg/kg				
Non-carcinogenic PAHs				
Naphthalene	0.038 U	0.24	0.038 U	0.13
2-Methylnaphthalene	0.038 U	0.096 J	0.038 U	0.05 J
Acenaphthylene	0.038 U	0.14	0.038 U	0.045 J
Acenaphthene	0.038 U	0.024 J	0.038 U	0.011 J
Flourene	0.038 U	0.036 J	0.038 U	0.011 J
Phenanthrene	0.015 J	1.2	0.038 U	0.64
Anthracene	0.038 U	0.19	0.038 U	0.15
Fluoranthene	0.12	4.9	0.038 U	2.6
Pyrene	0.12	4.9	0.038 U	3.0
Benzo(g,h,i)perylene	0.019 J	1.1	0.038 U	1.1
Carcinogenic PAHs				
Benzo(a)anthracene	0.042	3.6	0.038 U	2.6
Chrysene	0.15	4.2	0.038 U	4.0
Benzo(b)fluoranthene	0.077 T	4.6 T	0.038 U	4.2 T
Benzo(k)fluoranthene	0.077 T	4.6 T	0.038 U	4.2 T
Benzo(a)pyrene	0.023 J	1	0.038 U	0.46
Ideno(1,2,3-cd)pyrene	0.015 J	0.83	0.038 U	0.91
Dibenzo(a,h)anthracene	0.038 U	0.29	0.038 U	0.27
Total cPAHs (a)	0.33	14.5	0.13	12.4

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Table E-5 - Analytical Results from Test Pit Soil Samples (Continued)

Test Pit/Sample Number	TP502/S-1	TP502/S-2	TP503/S-1	TP503/S-2
Date Sampled	Feb 1992	Feb 1992	Feb 1992	Feb 1992
Sample Depth in Feet	0.5-1.5	3.0-4.0	0.5-1.5	3.0-4.0
Semivolatile Organic Compounds in mg/kg				
Non-carcinogenic PAHs				
Naphthalene	3	0.031 J	0.16 J	0.045 U
2-Methylnaphthalene	1.1	0.008 J	0.046 J	0.045 U
Acenaphthylene	6.1	0.015 J	0.23	0.0045 U
Acenaphthene	0.67	0.015 J	0.023 J	0.045 U
Flourene	0.2 U	0.008 J	0.092 J	0.045 U
Phenanthrene	34 D	0.065	1.1	0.054
Anthracene	11 D	0.019 J	0.18 J	0.014 J
Fluoranthene	87 D	0.180	2.4	0.11
Pyrene	140 D	0.33	3.2	0.17
Benzo(g,h,i)perylene	47 D	0.2	1.5	0.082
Carcinogenic PAHs				
Benzo(a)anthracene	40 D	0.1	1.6	0.05
Chrysene	50 D	0.16	1.2	0.059
Benzo(b)fluoranthene	72 TD	0.29 T	2.8 T	0.100 T
Benzo(k)fluoranthene	72 TD	0.29 T	2.8 T	0.100 T
Benzo(a)pyrene	59 D	0.23	1.7	0.077
Ideno(1,2,3-cd)pyrene	37 D	0.19	1.5	0.059
Dibenzo(a,h)anthracene	8.9 D	0.031 J	0.18 J	0.045 U
Total cPAHs (a)	267	1	9	0.37

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Table E-5 - Analytical Results from Test Pit Soil Samples (Continued)

Test Pit/Sample Number	TP504/S-1	TP504/S-2	TP505/S-1	TP505/S-2
Date Sampled	Feb 1992	Feb 1992	Feb 1992	Feb 1992
Sample Depth in Feet	0.5-1.5	2.5-3.5	0.5-1.5	2.5-3.5
Semivolatile Organic Compounds in mg/kg				
Non-carcinogenic PAHs				
Naphthalene	0.25	0.12 J	0.28	0.31 U
2-Methylnaphthalene	0.1	0.099 J	0.13 J	0.31 U
Acenaphthylene	0.044 J	0.06 J	0.37	0.31 U
Acenaphthene	0.036 J	0.14 J	0.19 U	0.31 U
Flourene	0.029 J	0.12 J	0.074 J	0.31 U
Phenanthrene	0.19	0.95	1.1	0.18 J
Anthracene	0.066 J	0.16 J	0.28	0.31 U
Fluoranthene	0.17	1.5	2.7	0.21 J
Pyrene	0.16	1.6	4.3	0.4
Benzo(g,h,i)perylene	0.2	0.46	1.9	0.18 J
Carcinogenic PAHs				
Benzo(a)anthracene	0.12	0.84	1.6	0.18 J
Chrysene	0.14	0.76	1.9	0.37
Benzo(b)fluoranthene	0.43 T	1.5 T	3.7 T	0.55 T
Benzo(k)fluoranthene	0.43 T	1.5 T	3.7 T	0.55 T
Benzo(a)pyrene	0.23	0.86	2.6	0.28
Ideno(1,2,3-cd)pyrene	0.18	0.42	1.4	0.18 J
Dibenzo(a,h)anthracene	0.073 U	0.2 U	0.19 U	0.31 U
Total cPAHs (a)	1.14	4.5	11.3	1.72

JOBS/235020TF.WK1

Table E-5 - Analytical Results from Test Pit Soil Samples (Continued)

Test Pit/Sample Number	TP506/S-1	TP506/S-2	TP507/S-1	TP507/S-2
Date Sampled	Feb 1992	Feb 1992	Feb 1992	Feb 1992
Sample Depth in Feet	0.5-1.5	3.0-4.0	0.1-1.5	3.0-4.0
Semivolatile Organic Compounds in mg/kg				
Non-carcinogenic PAHs				
Naphthalene	0.054	0.043 U	0.19 U	0.14
2-Methylnaphthalene	0.058	0.043 U	0.19 U	0.08
Acenaphthylene	0.021 J	0.043 U	0.093	0.059
Acenaphthene	0.017 J	0.12	0.056	0.021 J
Flourene	0.017 J	0.3	0.19 U	0.08
Phenanthrene	0.18	0.25	0.84	0.66
Anthracene	0.025 J	0.047	0.11 J	0.08
Fluoranthene	0.15	0.33	0.58	0.47
Pyrene	0.14	0.21	0.54	0.48
Benzo(g,h,i)perylene	0.033 J	0.043	0.13 J	0.085
Carcinogenic PAHs				
Benzo(a)anthracene	0.071	0.077	0.24	0.25
Chrysene	0.079	0.11	0.32	0.3
Benzo(b)fluoranthene	0.16 T	0.089 T	0.5 T	0.39 T
Benzo(k)fluoranthene	0.16 T	0.089 T	0.5 T	0.39 T
Benzo(a)pyrene	0.054	0.085	0.32	0.17
Ideno(1,2,3-cd)pyrene	0.046	0.047	0.13 J	0.08
Dibenzo(a,h)anthracene	0.042 U	0.043 U	0.19 U	0.053 U
Total cPAHs (a)	0.43	0.43	1.61	1.22

JOBS/235020TG.WK1

Table E-5 - Analytical Results from Test Pit Soil Samples (Continued)

Test Pit/Sample Number	TP508/S-1	TP508/S-2	TP509/S-1	TP509/S-2
Date Sampled	Feb 1992	Feb 1992	Feb 1992	Feb 1992
Sample Depth in Feet	0.5-1.5	2.5-3.5	0.5-1.5	2.5-3.5
Semivolatile Organic Compounds in mg/kg				
Non-carcinogenic PAHs				
Naphthalene	1.3	52	0.29	1.3
2-Methylnaphthalene	0.69	26	0.12	0.5
Acenaphthylene	1.1	74	0.13	1.9
Acenaphthene	1.1	90	0.024 J	0.19 J
Flourene	1.1	100	0.092	0.61
Phenanthrene	7.8	860 D	0.59	6.5
Anthracene	1.3	240	0.058	1.9
Fluoranthene	13	1,400 D	0.96	25 D
Pyrene	28 D	2,000 D	1.3	38.0 D
Benzo(g,h,i)perylene	5.1	580 D	0.29	9.8
Carcinogenic PAHs				
Benzo(a)anthracene	6.1	440 D	0.57	11
Chrysene	5.3	460 D	0.51	13
Benzo(b)fluoranthene	12 T	910 TD	0.87 T	28 T
Benzo(k)fluoranthene	12 T	910 TD	0.87 T	28 T
Benzo(a)pyrene	8.3	710 D	0.43	22 D
Ideno(1,2,3-cd)pyrene	4.3	400 D	0.24	9.2
Dibenzo(a,h)anthracene	1	94	0.049 U	2.5
Total cPAHs (a)	37	3,014	2.65	86

JOBS/235020TH.WK1

Table E-5 - Analytical Results from Test Pit Soil Samples (Continued)

Test Pit/Sample Number	TP600/S-1	TP601/S-1	TP602/S-1
Date Sampled	April 1992	April 1992	April 1992
Sample Depth in Feet	1.0-2.0	0-3.0	0-4.0
TCLP Metals in mg/L			
Arsenic	0.20 U	0.20 U	0.20 U
Cadmium	0.010 U	0.010 U	0.010 U
Chromium	0.10 U	0.10 U	0.10 U
Copper	0.20 U	0.20 U	0.40
Lead	0.10 U	0.10 U	0.10 U
Mercury	0.005 U	0.005 U	0.005 U
Nickel	0.10 U	0.10 U	0.20
Selenium	0.20 U	0.20 U	0.20 U
Silver	0.10 U	0.10 U	0.10 U
Zinc	0.70	0.20	1.30
Semivolatile Organic Compounds in mg/kg			
Non-carcinogenic PAHs			
Naphthalene	1,200	870	4.5
2-Methylnaphthalene	0.500	340	1.5
Acenaphthylene	0.072	1,400	6.4
Acenaphthene	0.110	450	0.57
Benzo(g,h,i)perylene	1.100	1,100	31
Fluorene	0.100	1,200	3.3
Phenanthrene	0.510	7,200	28
Anthracene	0.140	1,900	10
Fluoranthene	0.460	4,800	100
Pyrene	0.420	5,300	130
Carcinogenic PAHs			
Benzo(a)anthracene	0.250	1,500	45
Chrysene	0.320	1,800	55
Benzo(b)fluoranthene	0.760 T	2,100 T	75 T
Benzo(k)fluoranthene	0.760 T	2,100 T	75 T
Benzo(a)pyrene	0.300	1,900	59
Ideno(1,2,3-cd)pyrene	0.300	1,100	40
Dibenzo(a,h)anthracene	0.110	220	12
Total cPAHs (a)	2.040	9,120	286

Table E-5 - Analytical Results from Test Pit Soil Samples (Continued)

Test Pit/Sample Number	TP600/S-1	TP601/S-1	TP602/S-1
Date Sampled	April 1992	April 1992	April 1992
Sample Depth in Feet	1.0-2.0	0-3.0	0-4.0
TCLP Semivolatile Organics in mg/L			
m-Cresol	0.0040 U	0.0040 U	0.0040 U
o-Cresol	0.0040 U	0.0040 U	0.0040 U
p-Cresol	0.0040 U	0.0040 U	0.0040 U
1,4-Dichlorobenzene	0.0040 U	0.0040 U	0.0040 U
2,4-Dinitrotoluene	0.0080 U	0.0080 U	0.0080 U
Hexachlorobenzene	0.0080 U	0.0080 U	0.0080 U
Hexachloro-1,3-butadiene	0.0040 U	0.0040 U	0.0040 U
Hexachloroethane	0.0080 U	0.0080 U	0.0080 U
Nitrobenzene	0.0040 U	0.0040 U	0.0040 U
Pentachlorophenol	0.0040 U	0.0040 U	0.0040 U
2,4,5-Trichlorophenol	0.0080 U	0.0080 U	0.0080 U
2,4,6-Trichlorophenol	0.0080 U	0.0080 U	0.0080 U
Miscellaneous Parameters in mg/kg			
WTPHG	5.0 U	24	5.0
WTPHD	220	37,000	2,500
TPH (418.1)	380	200	120
PCBs in mg/kg			
Aroclor-1016	0.038 U	0.081 UJ	0.046 U
Aroclor-1221	0.077 U	0.160 UJ	0.094 U
Aroclor-1232	0.038 U	0.081 UJ	0.046 U
Aroclor-1242	0.038 U	0.081 UJ	0.046 U
Aroclor-1248	0.038 U	0.081 UJ	0.046 U
Aroclor-1254	0.071	0.081 UJ	0.046 U
Aroclor-1260	0.038 U	0.081 UJ	3.400

JOBS/235020TI.wk1

Table E-5 - Analytical Results from Test Pit Soil Samples (Continued)

Sample location:	TP600/S-1	TP601/S-1	TP602/S-1
Date sampled:	April 1992	April 1992	April 1992
Sample depth in feet:	1.0-2.0	0-3.0	0-4.0
Volatile Organic Compounds in mg/kg			
Methylene Chloride	0.002 U	0.005	0.002 U
Acetone	0.005	0.014	0.006 U
Benzene	0.002 U	0.090	0.002 U
Toluene	0.002 U	0.019	0.002 U
Styrene	0.002 U	0.005	0.002 U
Total Xylenes	0.002 U	0.006	0.002 U

Notes:

U - Indicates compound was analyzed for but not detected at the detection limit indicated.

J - Indicates an estimated value.

B - Indicates analyte was detected in laboratory method blank.

T - Flagged values represent sum of two co-eluting compounds.

D - Value reported derived from analysis of a diluted sample or sample extract.

(a) - Total cPAHs were calculated using one-half the detection limit values for non-detected results.

(b) - After silica gel cleanup.

NA - Not analyzed.

JOBS/235020TJ.wk1

Table E-5 - Analytical Results from Test Pit Soil Samples (Continued)

Test Pit/Sample Number	TP701/S-1	TP702/S-1	TP702/S-2	TP703/S-1
Date Sampled	June 1992	June 1992	June 1992	June 1992
Sample Depth in Feet	1.0-2.5	0.5-1.5	2.0-3.0	1.0-2.0
Semivolatile Organic Compounds in mg/kg				
Non-carcinogenic PAHs				
Naphthalene	0.240	110.0	0.360	0.064
2-Methylnaphthalene	0.190	69.0 UB	0.230	0.022 J
Acenaphthylene	0.098	500.0	1.50	0.047
Acenaphthene	0.140	330.0	0.680	0.037 U
Flourene	0.110	520.0	1.40	0.014 J
Phenanthrene	0.680	3500.0	9.30	0.190
Anthracene	0.130	1200.0	2.30	0.049
Fluoranthene	0.790	3100.0 B	5.70	0.470
Pyrene	1.200	3500.0 B	6.90	0.730
Benzo(g,h,i)perylene	0.390	630.0	1.00	0.400
Carcinogenic PAHs				
Benzo(a)anthracene	0.700	820.0	1.8	0.300
Chrysene	0.830	940.0	1.9	0.370
Benzo(b)fluoranthene	0.870 T	1500.0 T	2.7 T	0.660 T
Benzo(k)fluoranthene	0.870 T	1500.0 T	2.7 T	0.660 T
Benzo(a)pyrene	0.680	1300.0	2.2	0.450
Ideno(1,2,3-cd)pyrene	0.320	730.0	1.1	0.380
Dibenzo(a,h)anthracene	0.098	200.0	0.340	0.120
Total cPAHs (a)	3.5	5490	10.0	2.3

JOBS/235020TL.WK1

Table E-5 - Analytical Results from Test Pit Soil Samples (Continued)

Test Pit/Sample Number	TP703/S-2	TP704/S-1	TP704/S-2	TP705/S-1
Date Sampled	June 1992	June 1992	June 1992	June 1992
Sample Depth in Feet	3.5-4.5	1.0-2.0	3.5-4.5	1.0-2.0
Semivolatile Organic Compounds in mg/kg				
Non-carcinogenic PAHs				
Naphthalene	0.043 U	0.029 J	0.180	0.093
2-Methylnaphthalene	0.043 U	0.016 J	0.140	0.037 J
Acenaphthylene	0.043 U	0.009 J	0.150	0.077
Acenaphthene	0.043 U	0.008 J	0.180	0.200
Flourene	0.043 U	0.014 J	0.200	0.170
Phenanthrene	0.021 J	0.074	0.900	1.400
Anthracene	0.043 U	0.017 J	0.110	0.270
Fluoranthene	0.037 J	0.170	1.200	1.300
Pyrene	0.043	0.160	1.700	1.900
Benzo(g,h,i)perylene	0.046	0.067	0.095 U	0.420
Carcinogenic PAHs				
Benzo(a)anthracene	0.020 J	0.097	0.860	0.730
Chrysene	0.021 J	0.120	0.720	0.670
Benzo(b)fluoranthene	0.040 JT	0.160 T	1.400 T	1.000 T
Benzo(k)fluoranthene	0.040 JT	0.160 T	1.400 T	1.000 T
Benzo(a)pyrene	0.025 J	0.096	0.870	0.810
Ideno(1,2,3-cd)pyrene	0.029 J	0.068	0.470	0.530
Dibenzo(a,h)anthracene	0.043 U	0.040 U	0.095 U	0.110
Total cPAHs (a)	0.14	0.54	4.3	3.9

JOBS/235020TM.WK1

Table E-5 - Analytical Results from Test Pit Soil Samples (Continued)

Test Pit/Sample Number	TP705/S-2	TP706/S-1	TP707/S-1	TP707/S-2
Date Sampled	June 1992	June 1992	June 1992	June 1992
Sample Depth in Feet	3.0-4.0	1.0-2.0	1.5-2.5	4.5-5.5
Semivolatile Organic Compounds in mg/kg				
Non-carcinogenic PAHs				
Naphthalene	1.100	0.027 J	0.170	20.0
2-Methylnaphthalene	0.480	0.008 J	0.110	9.6 UB
Acenaphthylene	0.690	0.050	0.036 U	26.0
Acenaphthene	2.900	0.037 U	0.160	19.0
Flourene	2.600	0.017 J	0.130	26.0
Phenanthrene	21.000	0.270	0.670	210.0
Anthracene	5.300	0.060	0.110	39.0
Fluoranthene	27.000	0.860	0.650	360.0
Pyrene	32.000	1.300	0.620	470.0
Benzo(g,h,i)perylene	7.600	0.400	0.340	140.0
Carcinogenic PAHs				
Benzo(a)anthracene	9.900	0.390	0.240	86.0
Chrysene	11.000	0.370	0.220	80.0
Benzo(b)fluoranthene	15.000 T	0.570 T	0.420 T	260.0 T
Benzo(k)fluoranthene	15.000 T	0.570 T	0.420 T	260.0 T
Benzo(a)pyrene	12.000	0.420	0.150	150.0
Ideno(1,2,3-cd)pyrene	8.500	0.340	0.087	130.0
Dibenzo(a,h)anthracene	1.900	0.078	0.045	36.0
Total cPAHs (a)	58.3	2.2	1.2	742

JOBS/235020TN.WK1

Table E-5 - Analytical Results from Test Pit Soil Samples (Continued)

Test Pit/Sample Number	TP707/S-2D	TP708/S-1	TP708/S-2	TP709/S-1
Date Sampled	June 1992	June 1992	June 1992	June 1992
Sample Depth in Feet	4.5-5.5	0.5-1.5	2.5-3.5	1.5-2.5
Semivolatile Organic Compounds in mg/kg				
Non-carcinogenic PAHs				
Naphthalene	16.0	0.570 U	1.400	0.100 J
2-Methylnaphthalene	5.2 UB	0.570 U	0.560	0.520 U
Acenaphthylene	15.0	0.091 J	1.400	0.520 U
Acenaphthene	13.0	0.570 U	1.200	0.520 U
Flourene	14.0	0.570 U	1.200	0.520 U
Phenanthrene	140.0	0.630	9.700	0.590
Anthracene	39.0	0.130 J	2.700	0.100 J
Fluoranthene	360.0	0.870	16.000	0.780
Pyrene	490.0	1.400	22.000	0.880
Benzo(g,h,i)perylene	120.0	0.670	9.100	0.360 J
Carcinogenic PAHs				
Benzo(a)anthracene	120.0	0.860	10.000	0.410 J
Chrysene	140.0	1.500	13.000	1.100
Benzo(b)fluoranthene	260.0 T	2.000 T	21.000 T	1.300 T
Benzo(k)fluoranthene	260.0 T	2.000 T	21.000 T	1.300 T
Benzo(a)pyrene	180.0	0.720	14.000	0.520 U
Ideno(1,2,3-cd)pyrene	130.0	0.660	12.000	0.390 J
Dibenzo(a,h)anthracene	26.0	0.570 U	2.400	0.190 J
Total cPAHs (a)	856	5.7	72.4	3.4

JOBS/235020TO.WK1

Table E-5 - Analytical Results from Test Pit Soil Samples (Continued)

Test Pit/Sample Number	TP709/S-2	TP710/S-1	TP711/S-1	TP711/S-2
Date Sampled	June 1992	June 1992	June 1992	June 1992
Sample Depth in Feet	4.0-5.0	0.5-1.5	1.0-2.0	3.0-4.0
Semivolatile Organic Compounds in mg/kg				
Non-carcinogenic PAHs				
Naphthalene	0.076	4.100	0.630 U	0.100 J
2-Methylnaphthalene	0.100	1.100	0.630 U	0.220 U
Acenaphthylene	0.057	8.600	0.630 U	0.220 U
Acenaphthene	0.027 J	0.300 J	0.630 U	0.220 U
Flourene	0.034 J	2.100	0.630 U	0.220 U
Phenanthrene	0.230	28.000	0.870	0.530
Anthracene	0.033 J	6.500	0.630 U	0.220 U
Fluoranthene	0.310	78.000	0.440 J	0.790
Pyrene	0.410	130.000	0.420 J	0.480
Benzo(g,h,i)perylene	0.300	26.000	0.460 J	0.180 J
Carcinogenic PAHs				
Benzo(a)anthracene	0.250	44.000	0.630 U	0.310
Chrysene	0.240	53.000	0.380 J	0.350
Benzo(b)fluoranthene	0.450 T	82.000 T	0.560 JT	0.570 T
Benzo(k)fluoranthene	0.450 T	82.000 T	0.560 JT	0.570 T
Benzo(a)pyrene	0.250	60.000	0.340 J	0.230
Ideno(1,2,3-cd)pyrene	0.180	30.000	0.330 J	0.160 J
Dibenzo(a,h)anthracene	0.040 U	8.800	0.630 U	0.220 U
Total cPAHs (a)	1.4	278	1.6	1.6

JOBS/235020TP.WK1

Table E-5 - Analytical Results from Test Pit Soil Samples (Continued)

Test Pit/Sample Number	TP712/S-1	TP712/S-2	TP713/S-1	TP713/S-2
Date Sampled	June 1992	June 1992	June 1992	June 1992
Sample Depth in Feet	1.5-2.5	3.5-4.5	1.5-2.5	3.5-4.5
Semivolatile Organic Compounds in mg/kg				
Non-carcinogenic PAHs				
Naphthalene	0.610 U	0.088	0.200 U	0.045 U
2-Methylnaphthalene	0.610 U	0.057	0.200 U	0.045 U
Acenaphthylene	0.610 U	0.049	0.041 J	0.015 J
Acenaphthene	0.610 U	0.039 U	0.200 U	0.045 U
Flourene	0.610 U	0.020 J	0.200 U	0.045 U
Phenanthrene	0.820 B	0.270 B	0.150 UJB	0.110 B
Anthracene	0.110 J	0.036 J	0.041 J	0.018 J
Fluoranthene	0.960	0.560	0.270	0.320
Pyrene	0.890 B	0.640 B	0.360	0.300 B
Benzo(g,h,i)perylene	0.480 J	0.340	0.460	0.130
Carcinogenic PAHs				
Benzo(a)anthracene	0.660	0.450	0.270	0.400
Chrysene	0.860	0.380	0.270	1.100
Benzo(b)fluoranthene	1.000 T	0.710 T	0.490 T	1.400 T
Benzo(k)fluoranthene	1.000 T	0.710 T	0.490 T	1.400 T
Benzo(a)pyrene	0.600 J	0.380	0.260	0.110
Ideno(1,2,3-cd)pyrene	0.410 J	0.260	0.200	0.140
Dibenzo(a,h)anthracene	0.610 U	0.110	0.200 U	0.045 U
Total cPAHs (a)	3.5	2.3	1.5	3.2

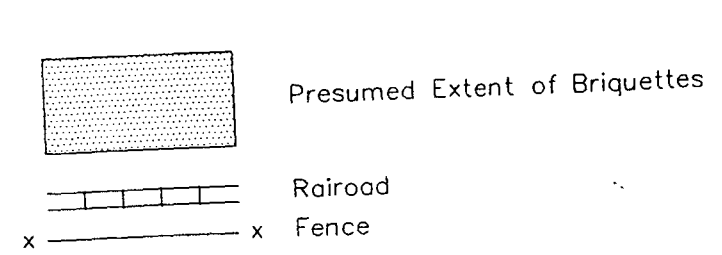
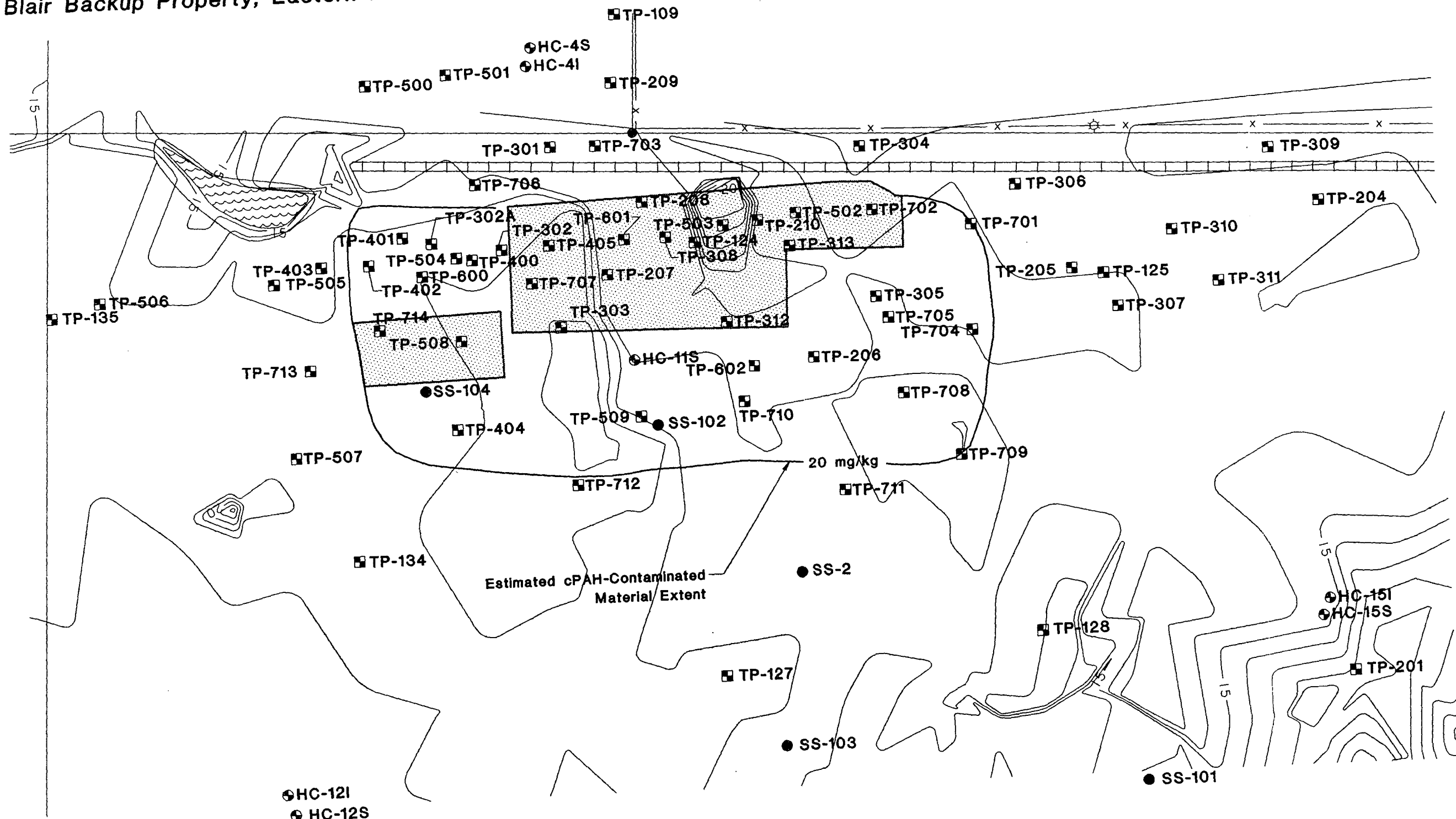
JOBS/235020TQ.WK1

Table E-5 - Analytical Results from Test Pit Soil Samples (Continued)

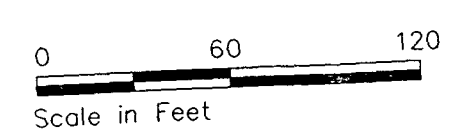
Test Pit/Sample Number	TP714/S-1	TP714/S-2
Date Sampled	June 1992	June 1992
Sample Depth in Feet	1.0-2.0	3.0-4.0
Semivolatile Organic Compounds in mg/kg		
Non-carcinogenic PAHs		
Naphthalene	1.700	24.00
2-Methylnaphthalene	1.200	6.30 UJB
Acenaphthylene	2.900	52.00
Acenaphthene	0.990	3.20 J
Flourene	3.400	32.00
Phenanthrene	26.000 B	330.00
Anthracene	6.900	80.00
Fluoranthene	27.000	680.00 B
Pyrene	45.000 B	1000.00 B
Benzo(g,h,i)perylene	11.000	350.00
Carcinogenic PAHs		
Benzo(a)anthracene	12.000	280.00
Chrysene	15.000	340.00
Benzo(b)fluoranthene	22.000 T	560.00 T
Benzo(k)fluoranthene	22.000 T	560.00 T
Benzo(a)pyrene	17.000	420.00
Ideno(1,2,3-cd)pyrene	9.600	350.00
Dibenzo(a,h)anthracene	2.800	68.00
Total cPAHs (a)	78.4	2,018

JOBS/235020TR.WK1

Site and Exploration Plan Blair Backup Property, Eastern Arm OFA/Pennwalt Area



- Exploration Location and Number
- TP-203 Test Pit
 - HC-12S Monitoring Well
 - SS-2 Surface Soil



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J-2350-20

ATTACHMENT E-1
FIELD EXPLORATIONS METHODS AND ANALYSIS

ATTACHMENT E-1 FIELD EXPLORATIONS METHODS AND ANALYSIS

This appendix documents the processes Hart Crowser uses in determining the nature of the soils underlying the project site addressed by this report. The discussion includes information on the following subjects:

- ▶ Explorations and Their Location
- ▶ Excavation of Test Pits

Explorations and Their Location

Subsurface explorations for this project include completing a series of test pits. The exploration logs within this appendix show our interpretation of the excavation, sampling, and testing data. They indicate the depth where the soils change. Note that the change may be gradual. In the field, we classified the samples taken from the explorations according to the methods presented on Figure E-2-1 - Key to Exploration Logs. This figure also provides a legend explaining the symbols and abbreviations used in the logs.

Location of Explorations. Figure E-1 shows the location of explorations, located by hand taping or pacing from existing physical features (property corners and surveyed wells). The ground surface elevations at these locations were interpreted from elevations shown on "Topographic Survey of a Portion of Parcel No. 9, Port of Tacoma" completed by HCE August 8, 1991. The method used determines the accuracy of the location and elevation of the explorations.

Excavation of Test Pits

A series of test pits, designated 100 through 700 series, were excavated across the site with a tractor-mounted backhoe subcontracted by our firm. The sides of these excavated pits offer direct observation of the subgrade soils. The test pits were located by and excavated under the direction of an engineering geologist from Hart Crowser. The geologist observed the soil exposed in the test pits and reported the findings on a field log. Our geologist took representative samples of soil types for testing at Hart Crowser's laboratory. He noted groundwater levels or seepage during excavation. The density/consistency of the soils (as presented parenthetically on the test pit logs to indicate their having been estimated) is based on visual observation only as disturbed soils cannot be measured for in-place density in the laboratory.

The test pit logs are presented on Figure E-2-5 through E-2-29 in Attachment E-2.

Boring Logs

Figures E-2-2 through E-2-4 in Attachment E-2 present logs of borings drilled in the vicinity of the area of concern. Selected subsurface soil samples from these borings were chemically analyzed and the logs are included here in for completeness.

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ATTACHMENT E-2
LOGS OF BORINGS AND TEST PITS

Key to Exploration Logs

Sample Description

Classification of soils in this report is based on visual field and laboratory observations which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field nor laboratory testing unless presented herein. Visual-manual classification methods of ASTM D 2488 were used as an identification guide.

Soil descriptions consist of the following:

Density/consistency, moisture, color, minor constituents, MAJOR CONSTITUENT, additional remarks.

Density/Consistency

Soil density/consistency in borings is related primarily to the Standard Penetration Resistance.

Soil density/consistency in test pits is estimated based on visual observation and is presented parenthetically on the test pit logs.

SAND or GRAVEL	Standard Penetration Resistance (N) in Blows/Foot	SILT or CLAY	Standard Penetration Resistance (N) in Blows/Foot	Approximate Shear Strength in TSF
Density		Consistency		
Very loose	0 - 4	Very soft	0 - 2	<0.125
Loose	4 - 10	Soft	2 - 4	0.125 - 0.25
Medium dense	10 - 30	Medium stiff	4 - 8	0.25 - 0.5
Dense	30 - 50	Stiff	8 - 15	0.5 - 1.0
Very dense	>50	Very stiff	15 - 30	1.0 - 2.0
		Hard	>30	>2.0

Moisture

Dry	Little perceptable moisture
Damp	Some perceptable moisture, probably below optimum
Moist	Probably near optimum moisture content
Wet	Much perceptable moisture, probably above optimum

Minor Constituents

Estimated Percentage

Not identified in description	0 - 5
Slightly (clayey, silty, etc.)	5 - 12
Clayey, silty, sandy, gravelly	12 - 30
Very (clayey, silty, etc.)	30 - 50

Legends

Sampling Test Symbols

BORING SAMPLES

	Split Spoon
	Shelby Tube
	Cuttings
	Core Run
*	No Sample Recovery
P	Tube Pushed, Not Driven

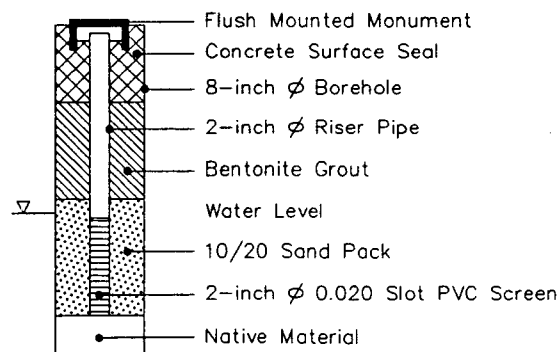
TEST PIT SAMPLES

	Grab (Jar)
	Bag
	Shelby Tube

Test Symbols

GS	Grain Size Classification
CN	Consolidation
TUU	Triaxial Unconsolidated Undrained
TCU	Triaxial Consolidated Undrained
TCD	Triaxial Consolidated Drained
QU	QU
DS	Direct Shear
K	Permeability
PP	Pocket Penetrometer Approximate Compressive Strength in TSF
TV	Torvane Approximate Shear Strength in TSF
CBR	California Bearing Ratio
MD	Moisture Density Relationship
AL	Atterberg Limits
	Water Content in Percent Liquid Limit Natural Plastic Limit
PID	Photoionization Reading

Groundwater Observations



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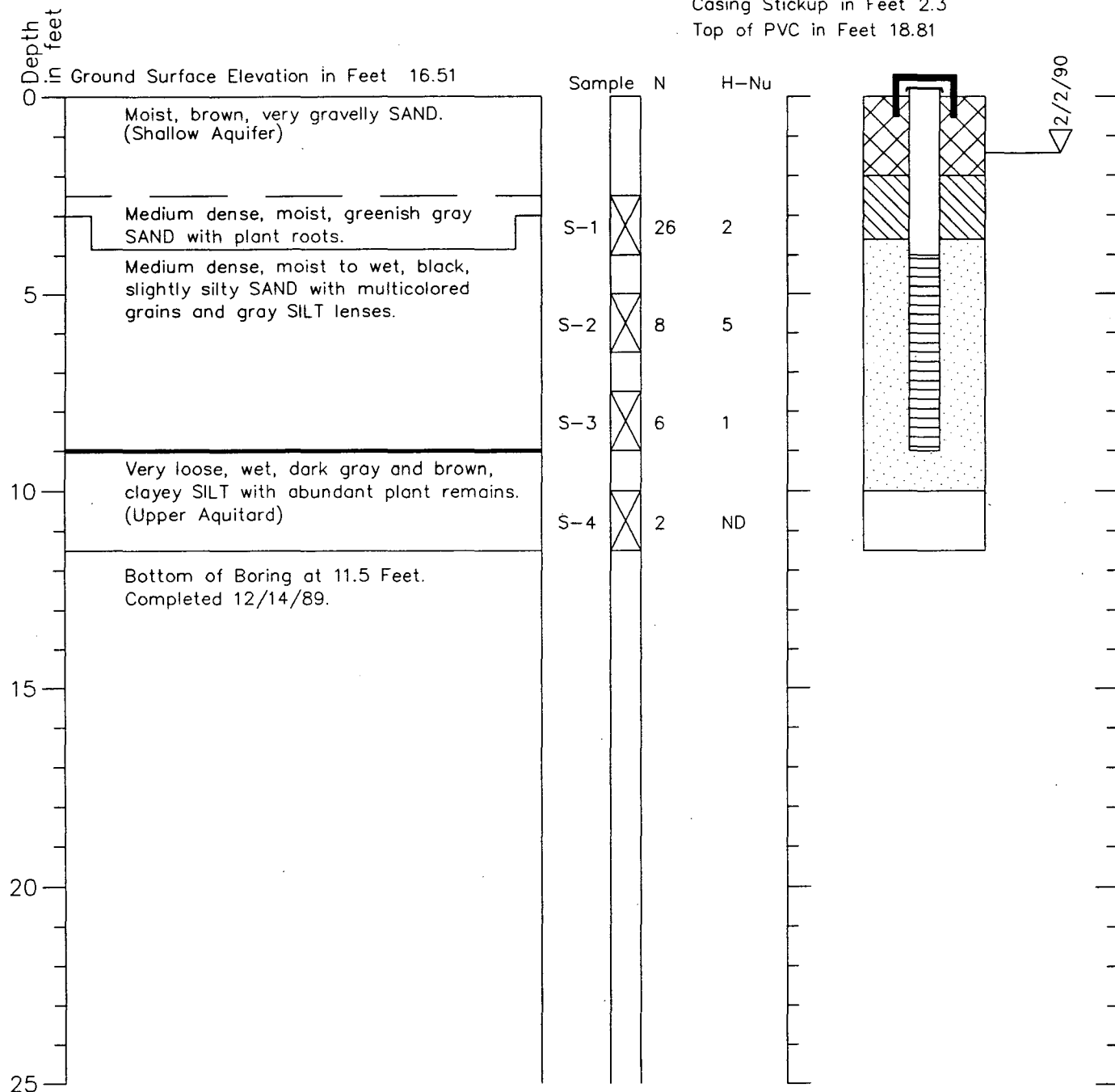
Figure E-2-1

Boring Log and Construction Data for Monitoring Well HC-4S

Geologic Log

Monitoring Well Design

Casing Stickup in Feet 2.3
Top of PVC in Feet 18.81



1. Refer to Figure E-2-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Bold line indicates boundary between major hydrogeologic units shown parenthetically.



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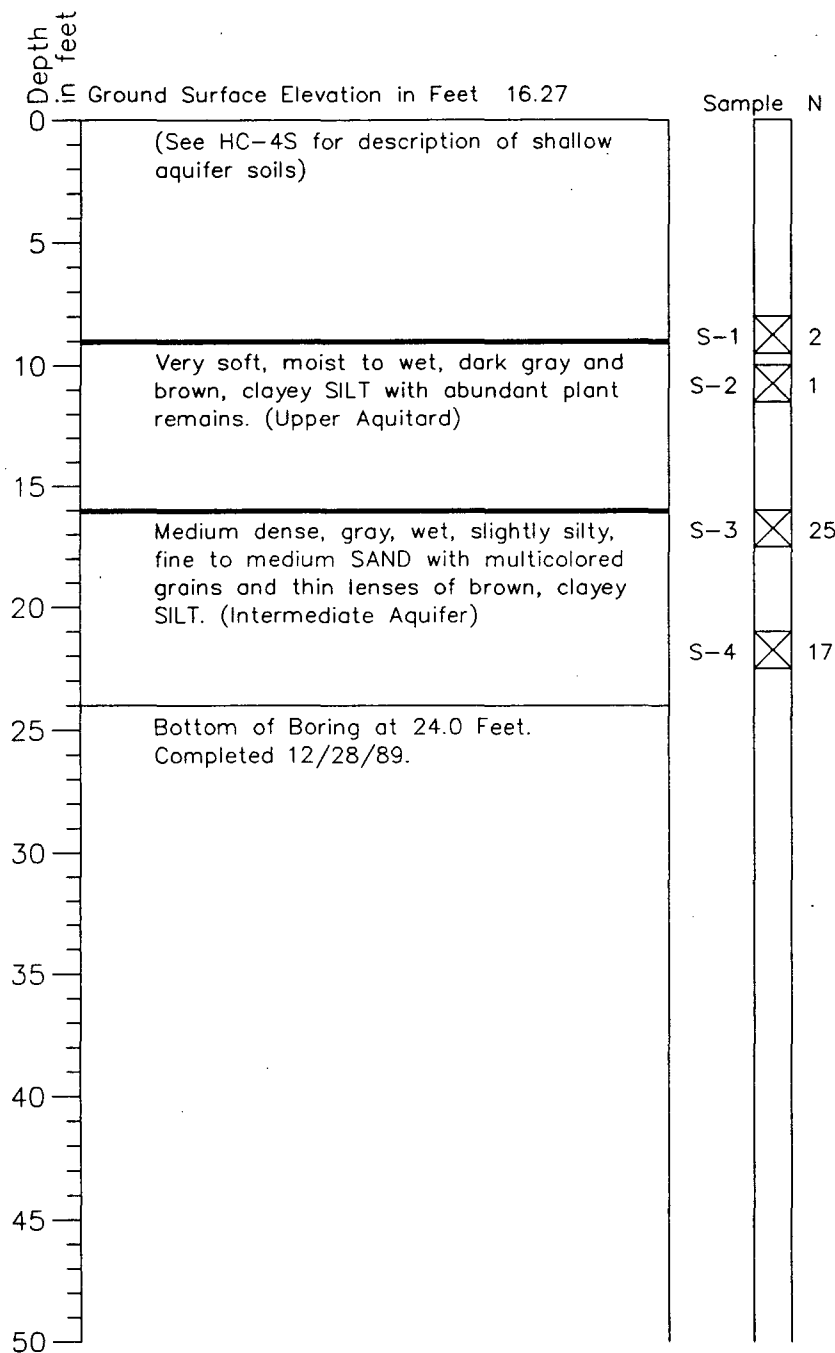
J-2350-20

12/89

Figure E-2-2

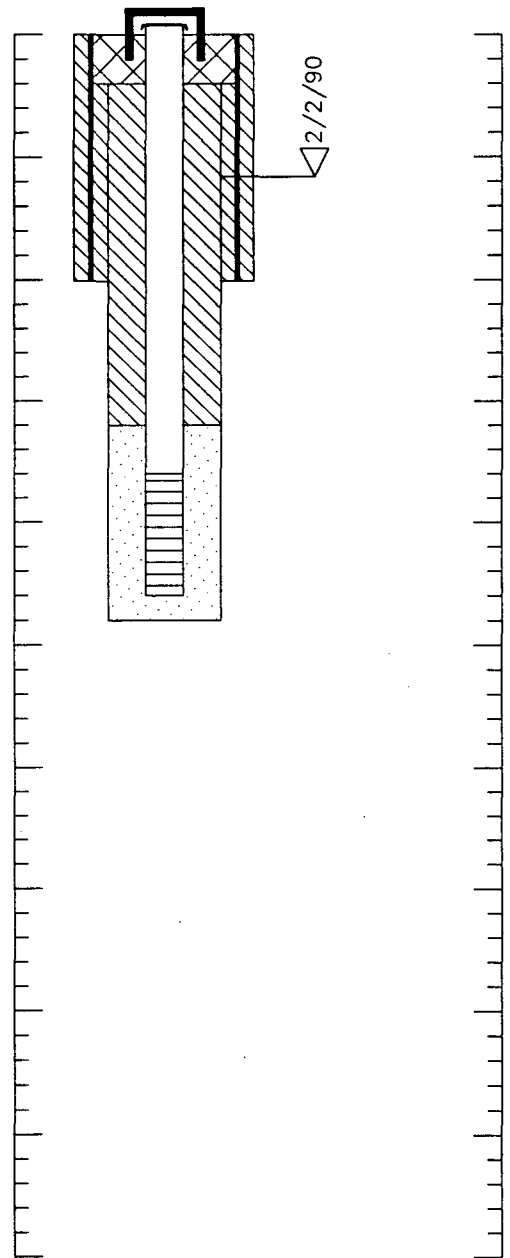
Boring Log and Construction Data for Monitoring Well HC-4I

Geologic Log



Monitoring Well Design

Casing Stickup in Feet 1.9
Top of PVC in Feet 18.10



1. Refer to Figure E-2-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.
4. Bold line indicates boundary between major hydrogeologic units shown parenthetically.



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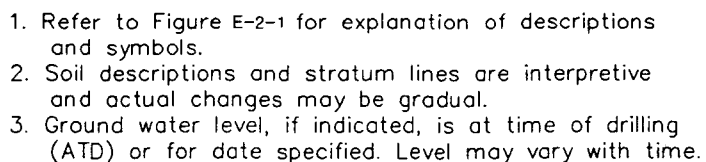
J-2350-20

12/89

Figure E-2-3

Geologic Log

Casing Stickup in Feet 2.1
Top of PVC in Feet 17.93



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J-2350-20

12/89

Figure E-2-4

Test Pit Log TP-109

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS Ground Surface Elevation in Feet 0.0
			0	
			1	Moist, brown, gravelly to very gravelly SAND.
			2	
S-1			3	Moist to wet, black, slightly silty SAND with multicolored grains and abundant plant remains at top of unit.
			4	
			5	Bottom of Test Pit at 4 Feet. Completed 12/7/89.
			6	
			7	
			8	
			9	
			10	
			11	
			12	
			13	
			14	
			15	

Test Pit Log TP-110

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS Ground Surface Elevation in Feet 0.0
			0	
S-1			1	Moist, brown, very gravelly SAND with large cobbles (2 to 7-inches).
			2	
S-2			3	Moist, greenish gray, gravelly SAND.
			4	Moist to wet, slightly silty to silty SAND with plant remains at upper contact.
			5	
			6	
			7	
S-3			8	Moist, gray, silty, fine SAND with greenish black, silty, fine SAND.
S-4			9	Moist, brown and black mottling, very clayey SILT with abundant organic matter (tide flat odor).
			10	
			11	Bottom of Test Pit at 10 Feet. Completed 12/7/89.
			12	Note: Slow water seepage at 5-foot depth. Water entering east sidewall was foamy.
			13	
			14	
			15	

1. Refer to Figure E-2-1 for explanation of descriptions and symbols.
 2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
- Denotes depth at which water was observed seeping into the excavation.

Test Pit Log TP-124

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
			0	Ground Surface Elevation in Feet 16.2
			1	River rock ballast.
S-1			2	Moist to wet, black, very gravelly SAND with wood debris, charcoal briquets, and cobbles. Creosote-like odor.
			3	
			4	Bottom of Test Pit at 3-1/2 Feet.
			5	Completed 12/5/89.
			6	
			7	
			8	
			9	

Test Pit Log TP-125

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
			0	Ground Surface Elevation in Feet 16.3
			1	Wood chip ballast with cobbles.
S-1			2	Moist, gray, very gravelly SAND with large quartz cobbles and wood debris.
			3	
S-2			4	Moist to wet, dark gray to black, sandy GRAVEL with small quartz fragments and angular black, coal-like material.
			5	
			6	Bottom of Test Pit at 5-1/2 Feet.
			7	Completed 12/5/89.
			8	
			9	

Test Pit Log TP-126

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
			0	Ground Surface Elevation in Feet 15.9
			1	Wood chip ballast.
S-1			2	Moist, grayish white, very gravelly to gravelly SAND consisting mainly of white quartz.
			3	
S-2			4	Wet, dark gray to black, medium SAND with multicolored grains.
			5	
			6	Bottom of Test Pit at 5-1/2 Feet.
			7	Completed 12/5/89.
			8	
			9	

1. Refer to Figure E-2-1 for explanation of descriptions and symbols.
 2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
- Denotes depth at which water was observed seeping into the excavation.

Test Pit Log TP-127

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 17.2
			0	Wood chips and rock ballast including pieces of slag and quartz.
			1	(Very dense), moist, tan, very sandy GRAVEL.
S-1			2	Moist to wet, dark gray to black, very gravelly SAND with
			3	cobbles, quartz fragments, and some slag.
			4	Bottom of Test Pit at 3-1/2 Feet.
			5	Completed 12/6/89.
			6	
			7	
			8	
			9	

Test Pit Log TP-128

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 18.1
			0	Wood chips and rock ballast including quartz, ore, slag, and
			1	river rock.
			2	
			3	Wood chips with moist to wet, dark brown, gravelly SAND with
S-1			4	some crushed quartz and slag material.
			5	
			6	Bottom of Test Pit at 5-1/2 Feet.
			7	Completed 12/6/89.
			8	
			9	

Test Pit Log TP-129

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground surface Elevation in Feet 15.0
			0	Wood chips and rock ballast (rocks consisting of river rock, quartz,
			1	and slag material).
			2	(Very dense), moist to wet, brown and tan, sandy GRAVEL (mainly
			3	river rock).
			4	(Dense), moist to wet, black SAND with small fragments of silver
			5	metallic-like material.
			6	Bottom of Test Pit at 4 Feet.
			7	Completed 12/6/89.
			8	
			9	

1. Refer to Figure E-2-1 for explanation of descriptions and symbols.
 2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
- Denotes depth at which water was observed seeping into the excavation.

Test Pit Log TP-130

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
			0	Ground Surface Elevation in Feet 0.0
			1	Moist, brown, very gravelly to gravelly SAND with wood chips.
S-1			2	Moist, gray, gravelly SAND with slag material and a layer of white, fine-grained material.
S-2			3	Moist to wet, black, gravelly SAND with multicolored grains and thin layers of white, fine-grained material.
			4	
			5	Bottom of Test Pit at 5 Feet.
			6	Completed 12/6/89.
			7	
			8	
			9	

Test Pit Log TP-131

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
			0	Ground Surface Elevation in Feet 0.0
			1	Moist, brown, very gravelly to gravelly SAND with wood chips and pieces of quartz, ore, and multicolored slag.
S-1			2	(Very dense), moist to wet, gray, very gravelly SAND with multicolored slag.
			3	
			4	
			5	Bottom of Test Pit at 5 Feet.
			6	Completed 12/6/89.
			7	
			8	
			9	

Test Pit Log TP-132

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
			0	Ground Surface Elevation in Feet 0.0
S-1			1	Moist to wet, brown, gravelly SAND with abundant wood chips and some slag. Creosote-like odor in soils.
			2	Bottom of Test Pit at 1-1/2 Feet.
			3	Completed 12/6/89.
			4	
			5	
			6	
			7	
			8	
			9	

1. Refer to Figure E-2-1 for explanation of descriptions and symbols.
 2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
- Denotes depth at which water was observed seeping into the excavation.

Test Pit Log TP-133

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
			0	Ground Surface Elevation in Feet 0.0
			1	Wood chip ballast with gravel.
S-1			2	Moist, olive green, gravelly SAND.
			3	
S-2			4	Moist to wet, gray, slightly silty, fine SAND.
			5	
			6	Bottom of Test Pit at 5 Feet.
			7	Completed 12/6/89.
			8	
			9	

Test Pit Log TP-134

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
			0	Ground Surface Elevation in Feet 0.0
			1	Wood chips and gravel ballast with river rock, quartz, and slag
			2	(Dense), moist, tan, very gravelly SAND.
S-1			3	Moist to wet, black, very gravelly SAND with multicolored slag and quartz.
			4	
			5	Bottom of Test Pit at 4 Feet.
			6	Completed 12/6/89.
			7	
			8	
			9	

Test Pit Log TP-135

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
			0	Ground Surface Elevation in Feet 0.0
			1	Moist, brown, gravelly SAND with multicolored grains, wood chips, wood and concrete debris.
			2	Moist to wet, brown, very gravelly SAND with some organics.
S-1			3	
			4	Bottom of Test Pit at 4 Feet.
			5	Completed 12/6/89.
			6	
			7	
			8	
			9	

1. Refer to Figure E-2-1 for explanation of descriptions and symbols.
 2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
- Denotes depth at which water was observed seeping into the excavation.

Test Pit Log TP-200

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 14-1/2
S-1			0	(Very dense), moist, very gravelly, fine to medium SAND with wood chips, wood fragments, river rock cobbles, and pink Ohio Ferro Alloy slag. Creosote-like odor.
			1	
			2	
			3	Wet, greenish gray, very gravelly SAND with cobbles.
			4	Bottom of Test Pit at 3 Feet.
			5	Completed 9/5/90.
			6	
			7	
			8	
			9	

Test Pit Log TP-201

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 14-3/4
S-1			0	Damp to moist, grayish brown, slightly gravelly to gravelly, fine SAND with abundant wood chips and Ohio Ferro Alloy slag fragments.
			1	
			2	(Very dense), moist, blackish-gray, very gravelly to gravelly SAND with large concrete blocks, wire, and silver, metallic Ohio Ferro Alloy slag.
			3	
			4	Bottom of Test Pit at 2 Feet.
			5	Completed 9/5/90.
			6	Note: Met refusal at bottom of excavation.
			7	
			8	
			9	

Test Pit Log TP-202

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 15-3/4
S-1			0	Moist, brownish gray, gravelly, fine to medium SAND with wood chips.
			1	
			2	Moist to wet, tan and dark gray, very gravelly SAND with iron staining.
			3	
			4	Wet, greenish gray, very gravelly SAND.
			5	
			6	Bottom of Test Pit at 4-1/2 Feet.
			7	Completed 9/5/90.
			8	
			9	

1. Refer to Figure E-2-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at time of excavation. Conditions may vary with time.

Test Pit Log TP-203

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 16
			0	
			1	Damp to moist, brownish gray, gravelly, fine to medium SAND with wood chips.
S-1			2	Moist to wet, grayish black, silty to very silty, fine SAND with wood fragments, Ohio Ferro Alloy slag and black, coal-like material, with shiny surfaces.
			3	
			4	
			5	Bottom of Test Pit at 4-1/2 Feet.
			6	Completed 9/5/90.
			7	
			8	
			9	

Test Pit Log TP-204

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 16
			0	
			1	Moist, grayish brown, very gravelly, fine SAND with abundant wood chips.
			2	Moist, tan and gray, very gravelly SAND with river rock and quartz fragments.
S-1			3	
			4	Moist to wet, black, slightly gravelly to gravelly SAND with increasing multicolored grains.
			5	
			6	
			7	Bottom of Test Pit at 6-1/2 Feet.
			8	Completed 9/5/90.
			9	

Test Pit Log TP-205

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 16-1/2
			0	
			1	Damp to moist, grayish brown, very gravelly SAND with abundant wood fragments and quartz.
S-1			2	Moist, blackish gray, gravelly SAND with quartz, wood fragments, and coal fragments.
			3	
			4	Moist to wet, light gray, gravelly coarse SAND (mainly quartz and black coal fragments). Creosote-like odor.
S-2			5	
			6	Bottom of Test Pit at 5 Feet.
			7	Completed 9/5/90.
			8	
			9	

1. Refer to Figure E-2-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at time of excavation. Conditions may vary with time.

Test Pit Log TP-206

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 16
			0	Moist, grayish brown, very gravelly SAND with abundant wood chips and Asarco slag.
			1	
S-1			2	Moist, tan and gray, very gravelly SAND with iron staining.
			3	Moist to wet, grayish black, gravelly SAND with Asarco and pink Ohio Ferro Alloy slag.
			4	
			5	Grading into black, gravelly to slightly gravelly SAND with multicolored grains.
			6	
			7	Bottom of Test Pit at 7 Feet.
			8	Completed 9/5/90.
			9	

Test Pit Log TP-207

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 15
			0	Damp to moist, light brown and gray, very gravelly SAND with wood debris and rock ballast (cobbles).
			1	
S-1			2	Moist, grayish black, gravelly SAND with abundant coal fragments, wood debris, charcoal briquets, and some Ohio Ferro Alloy slag and quartz. Creosote-like odor.
			3	
			4	Bottom of Test Pit 3-1/2 Feet.
			5	Completed 9/6/90.
			6	
			7	
			8	
			9	

Test Pit Log TP-208

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 15-1/2
			0	Damp to moist, light brown, very gravelly SAND with cobbles and wood debris.
			1	
S-1			2	Moist, black, gravelly SAND with charcoal fragments and coal.
			3	Moist to wet, gray, slightly gravelly SAND with small rounded grains and pink Ohio Ferro Alloy slag.
S-2			4	Wet, black, slightly gravelly SAND with multicolored grains.
			5	Bottom of Test Pit at 4 Feet.
			6	Completed 9/6/90.
			7	
			8	
			9	

1. Refer to Figure E-2-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at time of excavation. Conditions may vary with time.

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Figure E-2-12

Test Pit Log TP-209

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 16-1/2
			0	
			1	Dry to moist, light brown, very gravelly SAND with river rock.
S-1			2	
			3	Moist to wet, black SAND with multicolored grains.
			4	
			5	
			6	Bottom of Test Pit at 5-1/2 Feet.
			7	Completed 9/5/90.
			8	
			9	

Test Pit Log TP-210

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 15-3/4
			0	
			1	Dry to moist, light brown, very gravelly SAND (gravel ballast).
S-1			2	Moist, black, gravelly SAND with slag and coal fragments.
			3	Moist to wet, green, gravelly SAND with pink Ohio Ferro Alloy slag, charcoal, quartz, and coal.
			4	Wet, grayish black, gravelly SAND with small rounded grains, pink slag, and quartz.
			5	Bottom of Test Pit at 3-1/2 Feet.
			6	Completed 9/5/90.
			7	
			8	
			9	

Test Pit Log TP-211

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 17
			0	
			1	Moist, light brown, very gravelly SAND with river rock ballast.
S-1			2	
			3	Moist, greenish gray, gravelly SAND.
S-2			4	Moist, black, clayey SILT with abundant plant remains.
			5	
			6	Bottom of Test Pit at 5-1/2 Feet.
			7	Completed 9/5/90.
			8	
			9	

1. Refer to Figure E-2-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at time of excavation. Conditions may vary with time.

Test Pit Log TP-301

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
S-1			0	(Medium dense), moist, light brown, very gravelly SAND with trace of cobbles and abundant organics.
S-2			1	
			2	(Medium dense), moist, gray-green, very gravelly SAND.
S-3			3	(Medium dense), moist to wet, black, fine to medium SAND with occasional debris (metal pipe, wood, etc.).
			4	
			5	
			6	
			7	
			8	Bottom of Test Pit at 8 Feet.
			9	Completed 8/30/91.

Test Pit Log TP-302

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
			0	(Medium stiff), moist, gravelly, sandy SILT with abundant organic debris and trace of coal, increasing metal and wood debris with depth.
			1	
S-1			2	(Medium dense), moist, brown, fine to medium SAND with trace fine gravel.
			3	
			4	
			5	(Medium dense), moist to wet, black, gravelly SAND with occasional wood debris and various metal wires, cables, fasteners and pipes.
S-2			6	Strong petrochemical odor.
			7	
			8	Bottom of Test Pit at 6-1/4 Feet.
			9	Completed 8/30/91.

Note: Difficult to excavate deeper than 6-1/4 feet.

Test Pit Log TP-302A

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
			0	(Medium stiff), moist to dry, gravelly, sandy SILT with abundant organic debris.
			1	
			2	(Medium dense), moist, brown, fine to medium SAND with trace fine gravel.
			3	
			4	
			5	(Medium dense), moist to wet, black, gravelly SAND with wood debris and light petrochemical odor.
			6	
			7	Bottom of Test Pit at 5-1/2 Feet.
			8	Completed 8/30/91.
			9	

1. Refer to Figure E-2-1 for explanation of descriptions and symbols.
 2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
 3. Groundwater conditions, if indicated, are at time of excavation. Conditions may vary with time.
- Denotes depth at which water was observed seeping into the excavation.

Test Pit Log TP-303

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
S-1			0	(Medium dense), moist, yellow-brown, silty, sandy GRAVEL with abundant organics.
			1	Asphalt layer.
S-2			2	(Medium dense), moist, yellow-brown, gravelly SAND with scattered concrete blocks.
			3	(Medium dense), moist, black, silty, sandy GRAVEL.
			4	Bottom of Test Pit at 4 Feet.
			5	Completed 8/30/91.
			6	
			7	
			8	
			9	

Test Pit Log TP-304

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
S-1			0	(Medium dense), moist, black SAND and GRAVEL with some fine quartzite gravel and coal blocks.
			1	(Medium dense), moist, gray-green, gravelly SAND. (TILL FILL?)
			2	(Medium dense), moist, black, fine to medium SAND.
S-2			3	
			4	Bottom of Test Pit at 4-1/2 Feet.
			5	Completed 8/30/91.
			6	
			7	
			8	
			9	

Test Pit Log TP-305

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
S-1			0	(Medium dense), moist, black, silty, sandy GRAVEL with trace coal and abundant organic materials.
			1	(Medium dense), moist, gray-green, silty, clayey, coarse GRAVEL and wood. (TILL FILL?)
S-2			2	(Medium dense), moist, black, slightly silty, fine to medium SAND.
			3	
			4	Bottom of Test Pit at 4 Feet.
			5	Completed 8/30/91.
			6	
			7	
			8	
			9	

1. Refer to Figure E-2-1 for explanation of descriptions and symbols.
 2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
 3. Groundwater conditions, if indicated, are at time of excavation. Conditions may vary with time.
- Denotes depth at which water was observed seeping into the excavation.

Test Pit Log TP-306

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
S-1			0	(Medium dense), moist, brown, sandy, silty GRAVEL with some wood fragments and organic debris.
S-2			1	(Medium dense), moist, black GRAVEL and SAND (coal fragments).
S-3			2	(Medium dense), moist, gray-brown, slightly silty SAND and GRAVEL with abundant coal fragments.
			3	(Medium dense), moist, black, fine to medium SAND.
			4	Bottom of Test Pit at 4 Feet.
			5	Completed 8/30/91.
			6	
			7	
			8	
			9	

Test Pit Log TP-307

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
S-1			0	(Medium dense), moist, brown, sandy, silty GRAVEL with abundant wood chips, organic debris, and some quartzite gravel.
S-2			1	(Dense), moist, gray-green, silty to clayey, fine GRAVEL. (TILL FILL?)
S-3			2	(Medium dense), moist, black, sandy GRAVEL with abundant wood fragments and railroad tie size.
			3	(Medium dense), moist, black, slightly silty SAND with very slight creosote odor.
			4	Bottom of Test Pit at 5 Feet.
			5	Completed 8/30/91.
			6	
			7	
			8	
			9	

Test Pit Log TP-308

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
S-1			0	3 inches gravel fill over (dense), moist, green-gray, silty to clayey GRAVEL. (TILL FILL?)
S-2			1	(Medium dense), moist, black, very gravelly SAND with wood debris, charcoal briquettes, and cobbles.
			2	Wood, cobbles and gravel.
			3	Bottom of Test Pit at 4 Feet.
			4	Completed 8/30/91.
			5	Note: Test pit terminated at 4 feet due to difficult excavation.
			6	
			7	
			8	
			9	

1. Refer to Figure E-2-1 for explanation of descriptions and symbols.
 2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
 3. Groundwater conditions, if indicated, are at time of excavation. Conditions may vary with time.
- Denotes depth at which water was observed seeping into the excavation.

Test Pit Log TP-309

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
S-1			0	(Medium dense), wet, black, silty SAND and GRAVEL with abundant organic debris and some coal gravel.
S-2			1	
S-3			2	(Medium dense), moist, brown-green, gravelly SAND.
			3	(Medium dense), moist, black, slightly silty SAND with trace fine GRAVEL.
			4	Bottom of Test Pit at 4 Feet.
			5	Completed 8/30/91.
			6	
			7	
			8	
			9	

Test Pit Log TP-310

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
			0	(Medium dense), moist, brown, silty GRAVEL with wood and slag material.
			1	
			2	(Dense), moist, gray-green, silty to clayey GRAVEL. (TILL FILL?)
			3	(Medium dense), moist, brown, slightly silty GRAVEL with abundant quartzite and wood debris.
			4	
			5	(Medium dense), wet, brown, silty, sandy GRAVEL to gravelly SAND.
			6	Bottom of Test Pit at 5 Feet.
			7	Completed 8/30/91.
			8	
			9	

Test Pit Log TP-311

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
S-1			0	(Medium dense), moist, brown, silty GRAVEL with wood and slag material.
S-2			1	
			2	(Dense), moist, gray-green, silty to clayey GRAVEL. (TILL FILL?)
S-2			3	(Medium dense), moist, brown, slightly silty GRAVEL with quartzite.
			4	
S-4			5	(Medium dense), moist to wet, silty, sandy GRAVEL. Slight sheen on water.
			6	Bottom of Test Pit at 5 Feet.
			7	Completed 8/30/91.
			8	
			9	

1. Refer to Figure E-2-1 for explanation of descriptions and symbols.
 2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
 3. Groundwater conditions, if indicated, are at time of excavation. Conditions may vary with time.
- Denotes depth at which water was observed seeping into the excavation.

Test Pit Log TP-312

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
			0	Ground Surface Elevation in Feet 0.0
S-1			0	(Medium dense), moist, brown, silty GRAVEL.
			1	
S-2			2	(Medium dense), moist, black, slightly silty, gravelly SAND with trace coal. Charcoal briquettes observed at base of stratum.
			3	(Medium dense), moist, gray, crushed quartzite SAND.
			4	Bottom of Test Pit at 2-1/2 Feet.
			5	Completed 8/30/91.
			6	
			7	
			8	
			9	

Test Pit Log TP-313

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
			0	Ground Surface Elevation in Feet 0.0
			0	(Medium dense), moist, black, silty GRAVEL.
S-1			1	(Medium dense), moist, yellow-brown, silty to clayey GRAVEL.
			2	(Medium dense), moist, black, silty, sandy GRAVEL with organic debris and quartzite.
S-2			3	(Medium dense), moist, gray-green, fine to medium SAND.
			4	Bottom of Test Pit at 3 Feet.
			5	Completed 8/30/91.

1. Refer to Figure E-2-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at time of excavation. Conditions may vary with time.

Test Pit Log TP-400

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
			0	
			1	
			2	
S-1		CA	3	3 inches of (loose), moist, dark brown, gravelly SAND with wood chips and scattered pieces of slag, quartz, and coal over (dense), moist to wet, brown, gravelly, fine to medium SAND with metal (pipes, cables, wires, and sheets), and wood debris (railroad ties and timbers). Strong creosote-like odor.
			4	Bottom of Test Pit at 3-1/2 Feet. Completed 12/6/91.
			5	Note: Groundwater seepage observed at 3-foot depth. Hydrocarbon sheen on water.
			6	
			7	
			8	
			9	

Test Pit Log TP-401

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
			0	
			1	
			2	
			3	2 inches of (loose), moist, dark brown, slightly silty SAND with woodchips and scattered pieces of slag, quartz, and asphalt over (medium dense), moist, brown, gravelly, fine to medium SAND with large rounded cobbles and occasional metal pipes and asphalt debris.
S-1		CA	4	(Medium dense), moist to wet, gravelly SAND with decaying organic matter, quartz, and asphalt debris.
			5	Bottom of Test Pit at 5 Feet. Completed 12/6/91.
			6	Note: Groundwater seepage observed at 4-foot depth. Hydrocarbon sheen on water.
			7	
			8	
			9	

Test Pit Log TP-402

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
			0	
			1	
			2	
			3	3 inches of (loose), moist, dark brown, gravelly SAND with woodchips and scattered pieces of quartz over (dense), moist, brown, very gravelly SAND with concrete, wood (logs and boards), metal (rebar), and asphalt debris.
S-1			4	(Loose), wet, dark brown SAND with multicolored grains.
			5	Bottom of Test Pit at 3-1/2 Feet. Completed 12/6/91.
			6	Note: Groundwater seepage observed at 3-foot depth. Hydrocarbon sheen on water.
			7	
			8	
			9	

1. Refer to Figure E-2-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at time of excavation. Conditions may vary with time.

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12/91

Figure E-2-19

Test Pit Log TP-403

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
			0	Ground Surface Elevation in Feet 0.0
			1	2 inches of (loose), moist, dark brown, gravelly SAND with woodchip fragments and scattered quartz fragments over (medium dense),
			2	moist, brown, gravelly SAND with layers of asphalt and scattered wood debris.
			3	
S-1			4	(Medium dense to loose), moist to wet, black, silty, very gravelly, SAND with decaying organics and scattered quartz fragments.
			5	
			6	Bottom of Test Pit at 5-1/2 Feet.
			7	Completed 12/6/91.
			8	Note: Groundwater seepage encountered at 4-1/2-foot depth.
			9	

Test Pit Log TP-404

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
			0	Ground Surface Elevation in Feet 0.0
			1	2 inches of (loose), moist, dark brown, gravelly SAND with woodchips, occasional quartz, and slag fragments over (medium dense),
			2	moist, tan, slightly silty, gravelly SAND.
			3	(Medium dense to loose), moist to wet, dark gray, gravelly SAND (multicolored grains) with metal (wires and cables), concrete, and wood debris (boards). Creosote-like odor.
S-1		CA	4	
			5	Bottom of Test Pit at 5 Feet.
			6	Completed 12/6/91.
			7	
			8	
			9	

Test Pit Log TP-405

Sample	Water Content in Percent	Lab. Tests	Depth in Feet	SOIL DESCRIPTIONS
			0	Ground Surface Elevation in Feet 0.0
			1	2 inches of (loose), moist, dark brown, gravelly SAND with woodchips, quartz, and asphalt debris over 6 inches of (loose),
			2	moist, light brown, gravelly SAND over 3 inches of asphalt.
			3	(Medium dense to loose), moist, brown, gravelly SAND with cobbles, wood debris, and occasional metal debris (sheeting).
			4	(Medium dense to loose), moist to wet, black, slightly silty, gravelly, fine to medium SAND with coal and charcoal briquets. Slight creosote-like odor.
S-1			5	
			6	Bottom of Test Pit at 6 Feet.
			7	Completed 12/6/91.
			8	Note: Groundwater seepage encountered at 3.5-foot depth.
			9	

1. Refer to Figure E-2-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at time of excavation. Conditions may vary with time.

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J-2350-20

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Figure E-2-20

Test Pit Log TP-500

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
S-1		CA	0	6 inches of (medium dense), wet, tan, silty, sandy GRAVEL over
			1	(dense), moist, green gray, silty sandy GRAVEL (TILL FILL) with
			2	some wood fragments.
S-2		CA	3	(Loose), wet, green gray, slightly gravelly SAND.
			4	(Medium stiff), wet, dark green gray, silty CLAY.
			5	Bottom of Test Pit at 4 Feet.
			6	Completed 2/14/92.
			7	
			8	
			9	

Test Pit Log TP-501

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
S-1		CA	0	6 inches of (medium dense), wet, tan, silty, sandy GRAVEL over
			1	(dense), moist, green gray, silty, sandy GRAVEL (TILL FILL) with
			2	some wood fragments.
S-2		CA	3	(Loose), wet, green gray, slightly gravelly SAND.
			4	(Medium stiff), wet, dark green gray, silty CLAY.
			5	Bottom of Test Pit at 4 Feet.
			6	Completed 2/14/92.
			7	
			8	
			9	

Test Pit Log TP-502

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
S-1		CA	0	2 inches of gravel over (dense), damp, gray, silty GRAVEL with
			1	some wood.
			2	(Medium dense), brown, silty, sandy GRAVEL with some bricks and
			3	steel cable.
S-2		CA	3	(Loose), moist, gray, slightly gravelly SAND.
			4	(Medium dense), wet, silty, sandy GRAVEL with very fine to fine
			5	pebbles.
			6	Bottom of Test Pit at 3-1/2 Feet.
			7	Completed 2/13/92.
			8	
			9	

1. Refer to Figure E-2-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at time of excavation. Conditions may vary with time.

Test Pit Log TP-503

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
S-1		CA	0	(Medium dense), damp, yellow brown, silty, sandy GRAVEL with old wire, glass and some wood. Asphalt sample collected at 6 inches.
			1	
			2	(Medium dense), damp, dark brown, silty, sandy GRAVEL and abundant wood debris. (FILL)
			3	
			4	
			5	
			6	
S-2		CA	7	(Very dense), damp, green gray, silty, sandy GRAVEL with cobble-sized rocks. (TILL FILL)
			8	
			9	
				Bottom of Test Pit at 9 Feet. Completed 2/14/92.

Test Pit Log TP-504

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
S-1		CA	0	Sandy gravel mixed with chunks of asphalt. Asphalt sample collected at 9 inches.
			1	(Medium dense), wet, yellow brown, sandy GRAVEL.
			2	
S-2		CA	3	(Medium dense), wet, dark gray, slightly gravelly, very silty SAND with bricks and wood debris. (FILL)
			4	
				Bottom of Test Pit at 4 Feet. Completed 2/13/92.

Test Pit Log TP-505

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
S-1		CA	0	6 inches of (medium dense), moist, dark brown, silty, sandy GRAVEL over (medium dense), moist, yellow brown, silty, sandy GRAVEL with some organics (wood). Asphalt chunks up to 1 foot. A 1/4-inch-thick piece of steel cable at 2-1/2-foot depth. Asphalt sample collected at 16 inches.
			1	
			2	
S-2		CA	3	(Medium dense), wet, dark brown, silty, gravelly SAND. Approximately 80% of this zone is wood.
			4	
				Bottom of Test Pit at 3-1/2 Feet. Completed 2/13/92.

1. Refer to Figure E-2-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at time of excavation. Conditions may vary with time.

Test Pit Log TP-506

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
S-1		CA	0	(Medium dense), moist, brown, silty, gravelly SAND with abundant wood organics and lenses of (medium stiff), moist, gray, silty CLAY.
S-2		CA	3	(Medium dense), wet, dark gray, silty, gravelly SAND with abundant wood. Petrochemical odor.
			4	Bottom of Test Pit at 4 Feet.
			5	Completed 2/13/92.

Test Pit Log TP-507

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
S-1		CA	0	(Medium dense), damp, brown, silty, sandy GRAVEL with abundant asphalt, steel wires, a large telephone pole section, and several pieces of rebar from 3- to 3-1/2-foot depth. Asphalt sample collected in this zone.
S-2		CA	3	
			4	Bottom of Test Pit at 3-1/2 Feet.
			5	Completed 2/13/92.

Test Pit Log TP-508

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
S-1		CA	0	6 inches of (loose), wet, dark brown, silty, sandy GRAVEL over (medium dense), moist, yellow brown, sandy GRAVEL with abundance of wood organics, 1-1/2-inch pipe, and some asphalt.
S-2		CA	3	(Medium dense), moist to wet, dark brown, silty, sandy GRAVEL with cobble-sized rocks and abundant wood fragments.
			4	Bottom of Test Pit at 3-1/2 Feet.
			5	Completed 2/13/92.

Test Pit Log TP-509

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
S-1		CA	0	(Medium dense), moist, dark grayish brown, silty, sandy GRAVEL with some organics (wood).
S-2		CA	3	Some pockets of quartz observed between 2.5 and 3 feet. Becomes silty, gravelly SAND.
			4	Bottom of Test Pit at 4 Feet.
			5	Completed 2/13/92.

1. Refer to Figure E-2-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at time of excavation. Conditions may vary with time.

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Figure E-2-23

Test Pit Log TP-600

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
S-2			0	(Soft), moist, black, sandy SILT.
S-1			1	(Loose), wet, dark brown, silty, sandy GRAVEL with moderate debris including asphalt, wire logs with creosote-like staining. Petroleum odor.
S-3			2	
			3	
			4	Bottom of Test Pit at 4 Feet.
			5	Completed 4/20/92.
			6	Note: Groundwater encountered at 3-foot depth. Hit concrete refusal at 4-foot depth.
			7	
			8	
			9	

Test Pit Log TP-601

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
S-2			0	(Dense), moist, gray and brown, sandy GRAVEL with cobbles and charcoal briquettes.
GS-1	33		1	
S-3			2	(Soft), moist, black, gravelly SILT with abundant wood-lumber debris and scattered metal debris.
			3	Bottom of Test Pit at 3 Feet.
			4	Completed 4/20/92.
			5	Note: Groundwater was not encountered. Hit concrete refusal at 3-foot depth.
			6	
			7	
			8	
			9	

Test Pit Log TP-602

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
S-2			0	(Loose), wet, black, gravelly, silty SAND with cobbles and slag material below 1-1/2-foot depth.
GS-1	33		1	
S-3			2	(Loose), wet, gray-brown; sandy SILT.
			3	
			4	Bottom of Test Pit at 4 Feet.
			5	Completed 4/20/92.
			6	Note: Groundwater encountered at 1-1/2-foot depth. Hit refusal (concrete slab) on several attempts. Refusal at 4-foot depth.
			7	
			8	
			9	

1. Refer to Figure E-2-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at time of excavation. Conditions may vary with time.

Test Pit Log TP-701

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
			0	Wood debris.
			1	(Very dense), brown, silty, gravelly SAND.
S-1			2	Becoming blue gray.
			2	(Dense), black, silty, gravelly SAND with slag debris.
			3	(Very dense), dark brown, silty, sandy GRAVEL with wood debris.
			4	Bottom of Test Pit at 3-1/4 Feet.
			5	Completed 6/9/92.
			6	
			7	
			8	
			9	

Test Pit Log TP-702

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
			0	Crushed rock.
S-1			1	Black charcoal layer (silt to gravel gradation) with creosote odor.
			2	(Loose), dark brown, slightly silty to silty, fine to medium SAND.
S-2			3	
			4	Bottom of Test Pit at 3-1/4 Feet.
			5	Completed 6/9/92.
			6	
			7	
			8	
			9	

Test Pit Log TP-703

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
			0	(Medium dense), brown, slightly silty, sandy GRAVEL with wire rope, manila rope, and organics.
S-1			1	
			2	(Loose), moist, dark brown, slightly gravelly, silty SAND.
			3	(Very loose), wet, dark brown, slightly silty to silty, fine to medium SAND.
S-2			4	
			5	Bottom of Test Pit at 4-3/4 Feet.
			6	Completed 6/9/92.
			7	
			8	
			9	

1. Refer to Figure E-2-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at time of excavation. Conditions may vary with time.

Test Pit Log TP-704

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
			0	1/4 foot of wood debris over (dense), brown, silty, sandy GRAVEL.
S-1			1	(Very dense), brown, sandy, very silty GRAVEL.
			2	
			3	Moist, dark brown, wood debris, cut wood, and wood shavings.
S-2			4	
			5	Bottom of Test Pit at 4-3/4 Feet.
			6	Completed 6/9/92.
			7	
			8	
			9	

Test Pit Log TP-705

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
			0	Wood Debris.
S-1			1	(Dense), brownish gray, silty, sandy GRAVEL with organics.
			2	
			3	(Loose), moist, dark gray, slightly silty to silty, fine to medium SAND.
S-2			4	
			5	Bottom of Test Pit at 4-1/2 Feet.
			6	Completed 6/9/92.
			7	
			8	
			9	

Test Pit Log TP-706

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
			0	(Medium dense), brown, slightly silty, sandy GRAVEL with organics (grass, roots, etc.).
S-1			1	
			2	
			3	Bottom of Test Pit at 2-1/4 Feet.
			4	Completed 6/9/92.
			5	
			6	
			7	
			8	
			9	

1. Refer to Figure E-2-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at time of excavation. Conditions may vary with time.

Test Pit Log TP-707

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
S-1			0	1/4 foot of wood debris over (dense), brown, silty, sandy GRAVEL with wood debris.
			1	Becoming dark brown.
S-2			2	
			3	Shiny tar-like black, silty SAND including charcoal briquettes with wrapped wire debris.
			4	
			5	
			6	
			7	Bottom of Test Pit at 3-3/4 Feet.
			8	Completed 6/9/92.
			9	

Test Pit Log TP-708

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
S-1			0	Wood debris.
			1	(Dense), damp, black, sandy, gravelly SILT with wood debris.
S-2			2	(Very dense), wet, gray to black, sandy, very silty, GRAVEL with wood
			3	wood debris.
			4	Bottom of Test Pit at 3-3/4 Feet.
			5	Completed 6/9/92.
			6	
			7	
			8	
			9	

Test Pit Log TP-709

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS
				Ground Surface Elevation in Feet 0.0
S-1			0	Wood Debris.
			1	Damp, black, silty, sandy GRAVEL with plastic bag debris.
S-2			2	
			3	Gray, gravelly, sandy SILT.
			4	(Very dense), moist to wet, dark gray to black, silty, sandy
			5	GRAVEL with wood debris, and slag.
			6	Bottom of Test Pit at 5-1/2 Feet.
			7	Completed 6/9/92.
			8	
			9	

1. Refer to Figure E-2-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at time of excavation. Conditions may vary with time.

Test Pit Log TP-710

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS Ground Surface Elevation in Feet 0.0
S-1			0 1 2	1/4 foot of Wood Debris over (dense), moist, black, sandy, very silty GRAVEL with charcoal debris.
			3 4 5 6 7 8 9	Bottom of Test Pit at 2 Feet. Completed 6/9/92.

Test Pit Log TP-711

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS Ground Surface Elevation in Feet 0.0
S-1			0 1 2 3	Damp, dark brown Wood Debris with gravels.
S-2			4 5 6 7 8 9	Moist to wet, black, silty, sandy GRAVEL with slag. Bottom of Test Pit at 4-1/4 Feet. Completed 6/9/92.

Test Pit Log TP-712

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS Ground Surface Elevation in Feet 0.0
S-1			0 1 2 3	Wood debris with dark brown silt, sand, gravel, and wire rope. (Very dense), dark gray to black, silty, sandy GRAVEL with organics and slag pockets.
S-2			4 5 6 7 8 9	Grades to less organics. Bottom of Test Pit at 5-1/4 Feet. Completed 6/9/92.

1. Refer to Figure E-2-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at time of excavation. Conditions may vary with time.

Test Pit Log TP-713

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS Ground Surface Elevation in Feet 0.0
			0	
			1	1/4 foot of wood chips and bark over (dense), damp, dark brown, very silty, sandy GRAVEL with organics.
S-1			2	
			3	(Medium dense), moist, dark gray to black, gravelly, sandy SILT with organics and wood chips.
S-2			4	
			5	▽
			6	Bottom of Test Pit at 5-1/2 Feet. Completed 6/9/92.
			7	
			8	
			9	
			10	
			11	
			12	
			13	
			14	
			15	

Test Pit Log TP-714

Sample	Water Content in Percent	Lab Tests	Depth in Feet	SOIL DESCRIPTIONS Ground Surface Elevation in Feet 0.0
			0	
			1	1/4 foot of wood debris over (dense), damp, brown, silty, sandy GRAVEL.
S-1			2	
			3	Moist, black, silty, sandy GRAVEL with wood debris, concrete, telephone cable, rebar, and charcoal briquets.
S-2			4	▽
			5	Bottom of Test Pit at 4-1/4 Feet. Completed 6/9/92.
			6	
			7	
			8	
			9	
			10	
			11	
			12	
			13	
			14	
			15	

1. Refer to Figure E-2-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at time of excavation. Conditions may vary with time.

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Figure E-2-29

APPENDIX F
POTENTIAL ARARS CONSIDERED FOR DEVELOPMENT
OF CLEANUP OBJECTIVES AND EVALUATION
OF REMEDIAL ALTERNATIVES

**APPENDIX F
POTENTIAL ARARS CONSIDERED FOR DEVELOPMENT
OF CLEANUP OBJECTIVES AND EVALUATION
OF REMEDIAL ALTERNATIVES**

What are ARARs?

Section 121 (d) of the Superfund Amendments and Reauthorization Act of 1986 (SARA) requires remedial actions at Superfund sites to attain the "applicable or relevant and appropriate" requirements of federal and state environmental laws and regulations. The MTCA requires that remedial actions meet cleanup standards at least as stringent as those under Section 121 (d). The NCP and the EPA guidance document "CERCLA Compliance with Other Laws Manual" (EPA, 1988c) provide supporting information regarding ARARs.

According to the NCP, applicable requirements are those promulgated under federal or state law that specifically address a hazardous substance, contaminant, remedial action, location, or other situation on a Superfund site. Relevant and appropriate requirements are those promulgated under federal and state law that are not directly applicable, but still address problems or situations sufficiently similar to those encountered at a Superfund site that their use is well suited to the particular site. Relevant and appropriate requirements are determined on a case-by-case basis.

EPA's guidance discusses three types of potential ARARs:

- ▶ **Chemical-specific ARARs** include those requirements that regulate the acceptable amount or concentration of a chemical that may be found in or released to the environment. These ARARs are presented in Table F-1 and are discussed below.
- ▶ **Location-specific ARARs** are those requirements that restrict the concentration of hazardous substances or the conduct of activities solely because they occur in special locations. These ARARs are presented in Table F-1 and are discussed below.
- ▶ **Action-specific ARARs** are those requirements that define acceptable management practices, and are usually specific to certain kinds of activities or technologies that can occur during the implementation of cleanup actions. These requirements are triggered by the particular activities that are selected to accomplish a cleanup.

The intent of this appendix is to present the ARARs evaluated to the extent necessary to select a preferred alternative. The MOA states that the cleanups must comply with ARARs. In addition, because the MOA states that the property must provide reasonable use for commercial and industrial purposes, our analysis of ARARs is directed toward such uses. ✓

Chemical-Specific ARARs

The chemical-specific ARARs were determined based on the media and constituents of concern identified in the Final Investigation Report and through additional supporting studies as discussed in Section 3 of this report. The problem materials identified for the Blair Backup property include the OFA slag, charcoal and PAH-contaminated soil, sandblast grit (that may have been derived from Asarco slag) and associated soil. The combined Blair properties alternative also considers that Asarco slag mixed with soil from the Blair Waterways property will be included in the Blair Backup cleanup plan.

The chemical-specific ARARS considered for the Blair Backup problem materials include the MTCA which addresses soil, surface water and groundwater protection levels and the state and federal Clean Water Act regulations for addressing surface water concerns as discussed below. These ARARs define acceptable exposure levels for site uses and were used in developing cleanup levels.

Model Toxics Control Act (MTCA, Chapter 70.105D RCW)

Consistent with the MOA, cleanup standards for the Blair Waterway Property have been developed in accordance with MTCA. MTCA is an applicable requirement under CERCLA. Section 3.0 discusses in more detail the specific objectives and numeric cleanup levels determined based on MTCA. In addition, the criteria used in the evaluation of cleanup alternatives are consistent with the evaluations specified under MTCA.

Clean Water Act (33 U.S.C. 1251-1387; 40 C.F.R., Parts 131, 125, 230)

The protection of aquatic resources within the Blair Waterway is a primary consideration in the development and selection of cleanup alternatives at the Property. The Clean Water Act (CWA) and associated Washington State Water Pollution Control Act (WPCA) provide sediment and water quality criteria and standards for protection of aquatic resources. Cleanup standards for protection of aquatic life are presented in Section 3.0 of this report.

Location-Specific ARARs

The location-specific ARARS identified should pose no particular constraints on the cleanup of the property as defined by the alternatives evaluated. The only location-specific ARAR identified includes the Puyallup Land Settlement Agreement under which this work is being performed.

Action-Specific ARARs

The action-specific ARARS are invoked based on the particular activities considered under the various alternatives. The key ARARs presented in Table F-1 that are discussed below relative to our assessment of potential applicability or relevance and appropriateness for the specific site cleanup activities considered include:

- ▶ RCRA Subtitle C (40 CFR 261)
- ▶ Washington State Hazardous Waste Management Act (Chapter 70.105 RCW)
- ▶ Washington State Solid Waste Management Act (Chapter 80.95 RCW)

RCRA Subtitle C (40 CFR 261)

Under RCRA, the OFA slag, the charcoal and PAH-contaminated soil, and the sandblast grit with associated soil would not designate as either a listed or characteristic hazardous waste. One of four samples of Asarco slag from the Blair Waterway property exceeded the threshold value for the characteristic of toxicity based on arsenic TCLP. However, because the slag alone is not representative of the soil/slag mixture to be remediated, it is likely that the soil/slag material will not designate as a RCRA characteristic waste and RCRA will not apply.

Washington State Hazardous Waste Management Act Regulations (Chapter 70.105 RCW)

The Washington state dangerous waste regulations are the state equivalent of the RCRA requirements. The state regulation includes an additional characteristic rule whereby any carcinogen which exceeds the threshold level of 100 mg/kg is designated as a dangerous waste. We understand the Department of Ecology is considering two applications to exempt arsenic-contaminated soil and arsenic slag from the definition of dangerous waste. If these applications are approved the Blair material will not be dangerous waste.

The charcoal and PAH-contaminated soil exceeding 100 mg/kg cPAHs, the sandblast grit, and the Asarco slag could potentially be considered dangerous waste under the state regulation. All the cleanup alternatives include either leaving these materials

on site (or within the area of contamination) or removal and off-site disposal. For the purpose of evaluating ARAR compliance for the alternative evaluation we have assumed the following conditions;

- ▶ For alternatives that leave the problem materials on site, (i.e., no waste is generated) the State Dangerous Waste regulations are not applicable. However, because the material does contain carcinogenic substances that exceed the 100 mg/kg characteristic, the substantive requirements of the state dangerous waste regulations would be relevant and appropriate and will be considered in determining appropriate cover and groundwater protection standards in the cleanup plan. CERCLA guidance provides for flexibility in design and closure when the requirements are only relevant and appropriate.
- ▶ For alternatives that remove the materials from the site (outside of the "area of contamination), the dangerous waste regulations become applicable as the materials will be generated, will need to be manifested, and thus disposed of in an approved hazardous waste facility.

Washington State Solid Waste Management Act (Chapter 80.95 RCW)

These regulations provide the minimal functional standards for landfilling of solid waste. Problem wastes (soils removed during cleanup of a remedial action site or other cleanup actions of substances not considered hazardous wastes) are exempt from the regulations. However, because of pending exemption applications of arsenic wastes from the dangerous waste regulations, these will be considered in designing an on-site cleanup.

**Table F-1 - Potential ARARs Considered for Development of Cleanup Objectives
and Evaluation of Remedial Alternatives**

Sheet 1 of 4

Authorizing Statute	Implementing Regulation	Potentially Applicable or Relevant and Appropriate?	Rationale
Chemical Specific ARARs			
Clean Water Act, 33 USC 1251-1387	Water Quality Standards, 40 CFR 131	Yes	Establishes surface water quality standards to protect aquatic life and human health.
Safe Drinking Water Act, 42 USC 300f-300j-11	National Primary and Secondary Drinking Water Regulations, 40 CFR 141 and 143	No	Drinking water standards not applicable because Shallow Aquifer is of insufficient natural quality and quantity to be used as a present or future drinking water source.
WA Model Toxics Control Act (MTCA), RCW 70.105D	MTCA Cleanup, WAC 173-340	Yes	Establishes cleanup standards for industrial soil and surface water, among other media.
WA MTCA, RCW 70.105D, and other authorities	Sediment Management Standards, WAC 173-204	No	No marine sediment on or adjacent to site, and no impact from site runoff to marine sediments.
WA Water Pollution Control Act, RCW 90.48	Water Quality Standards for Surface Waters, WAC 173-201	Yes	Establishes narrative and numeric surface water quality standards for waters of the state.
WA Water Pollution Control Act, RCW 90.48	Water Quality Standards for Groundwaters, WAC 173-200	No	Cleanup actions under MTCA or CERCLA are exempt from the groundwater quality standards.
Location Specific ARARs			
Floodplain Management, Executive Order 11988	Procedures on Floodplain Management and Wetlands Protection, 40 CFR 6, Appendix A	No	Site activities will not occur in floodplain.
Protection of Wetlands, Executive Order 11990	Procedures on Floodplain Management and Wetlands Protection, 40 CFR 6, Appendix A	No	Site actions will not occur in North Site Area.

Table F-1 - Continued

Sheet 2 of 4

Authorizing Statute	Implementing Regulation	Potentially Applicable or Relevant and Appropriate?	Rationale
Resource Conservation and Recovery Act (RCRA), Subtitle D, 42 USC 6941-6949a	Criteria for Classification of Solid Waste Disposal Facilities and Practices, 40 CFR 257	No	Provides criteria for facilities and practices involving flood-plains, endangered species, surface water, and groundwater.
Puyallup Tribe of Indian Settlement Act of 1989. Public Law 101-41	None	Yes	Actions are being conducted to meet tribal environmental standards for the Commencement Bay/Puyallup River Watershed
WA Solid Waste Management Act, RCW 70.95	Minimum Functional Standards for Solid Waste, WAC 173-304	No	Locational standards do not apply to disposal of problem waste.
WA Shoreline Management Act, RCW 90.58	Permits for Development on Shorelines of the State, WAC 173-14	No	No construction within 200 feet of shoreline is planned at the site.
Location Specific TBCs			
--	Pierce Co. Aquifer Ordinance 91-11952, Ch. 21.16	No	Governs management of aquifer recharge areas to protect water supply aquifers. No water supply aquifers to be impacted by site activities.
--	Tacoma Shoreline Ordinance, Ch. 3.10	No	Addresses Shoreline Management.
--	Tacoma Wetlands Ordinance, Ch. 13.11	Potential TBC	Establishes requirements for activities in or near wetlands.
Action-Specific ARARs			
Resource Conservation and Recovery Act (RCRA), Subtitle C, 42 USC 6921-6939b	Identification and Listing of Hazardous Waste, 40 CFR 261; Standards for Owners and Operators of TSD Facilities, 264	No	None of the wastes at the site are a RCRA characteristic or listed hazardous waste.

Table F-1 - Continued

Sheet 3 of 4

Authorizing Statute	Implementing Regulation	Potentially Applicable or Relevant and Appropriate?	Rationale
Resource Conservation and Recovery Act, Subtitle D, 42 USC 6941-6949a	Criteria for Classification of Solid Waste Disposal Facilities and Practices, 40 CFR 257	No	Establishes criteria for classifying solid waste disposal facilities (40 CFR 257), and performance standards for groundwater protection.
Hazardous Materials Transportation Act, 49 USC 1801-1812	U.S. Department of Transportation Regulations, 49 CFR 171-178	Yes	Regulates transport of hazardous materials.
Puyallup Tribal Council Resolution No. 71288	Puyallup Tribal Water Quality Program	Yes	Protects fishing rights, habitat values, surface water, and groundwater.
WA Hazardous Waste Management Act, RCW 70.105	Dangerous Waste, WAC 173-303	Yes	Defines dangerous wastes and sets requirements for generation, treatment, storage, and disposal of dangerous wastes; relevant for handling and storage of carcinogenic wastes exceeding 100 mg/kg (charcoal, sandblast grit, and Asarco slag). If within AOC disposal not an issue.
WA Solid Waste Management Act, RCW 80.95	Minimum Functional Standards for Solid Waste, WAC 173-304	Yes	Defines solid waste landfill design, operation, and closure standards. Substantive requirements for problem waste disposal may apply.
WA Clean Air Act, RCW 70.94	PSAPCA Regulations 1 and 3	Yes	Sets ambient air quality standards and acceptable source impact levels (ASILs) for any construction activity conducted at the site.

Table F-1 - Continued

Sheet 4 of 4

Authorizing Statute	Implementing Regulation	Potentially Applicable or Relevant and Appropriate?	Rationale
WA Model Toxics Control Act, RCW 70-1050	MTCA Cleanup WAC 173-340	Yes	Sets minimum cleanup standards for remedial actions.

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act.
CRF = Code of Federal Regulations
MTCA = Model Toxics Control Act
PSAPCA = Puget Sound Air Pollution Control Agency
RCRA = Resource Conservation and Recovery Act
RCW = Revised Code of Washington
TBC = To Be Considered
USC = United States Code
WA = Washington
WAC = Washington Administrative Code

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TABLE F-1

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APPENDIX G
COST ESTIMATE FOR BLAIR BACKUP REMEDIATION PROJECT

APPENDIX G
COST ESTIMATE FOR BLAIR BACKUP REMEDIATION PROJECT

This appendix includes the estimated costs for the seven remedial options for slag-contaminated soil discussed in Section 4.0 and ten remedial options for cPAH-contaminated material discussed in Section 5.0. The cost estimates presented herein have been prepared for guidance in project evaluation and implementation from the information available at the time of the estimate. The actual cost depends on many variables, including health and safety regulations, labor and equipment costs, the final project scope, and quantity of contaminated material. As a result, the final project costs would vary from the estimates presented herein.

SANDBLAST GRIT-CONTAMINATED SOIL ALTERNATIVES COST ESTIMATE

1 LANDFILL SANDBLAST GRIT-CONTAMINATED SOIL

Activity	Quantity	Unit	Cost	Total
Remediation				
Mobilization	1	EA	\$5,000	\$5,000
Haul and Dispose Grit Contaminated Soil	1,300	TON	\$275	\$357,500
Subtotal				\$362,500
Contingency (15%)				\$54,375
Subtotal				\$416,875
Engineering Administration (12%)				\$50,025
WSST (7.8%)				\$32,516
TOTAL				\$499,416

2 PLACE SANDBLAST GRIT-CONTAMINATED SOIL IN OFA/PENNWALT AREA

Activity	Quantity	Unit	Cost	Total
Remediation				
Mobilization	1	EA	\$5,000	\$5,000
Haul and Place Grit Contaminated Soil to OFA Area	1,000	CY.	\$6	\$6,000
Crushed Rock (4")	493	TON	\$12	\$5,916
Asphalt Paving (2-1/2")	221	TON	\$27	\$5,967
Fabric Interlayer and Seal Coat	1,600	SY	\$3.05	\$4,880
8" Sand and gravel cover	622	TON	\$6	\$3,732
Subtotal				\$22,883
Contingency (15%)				\$3,432
Subtotal				\$26,315
Engineering Administration (12%)				\$3,158
WSST (7.8%)				\$2,053
TOTAL				\$31,526

3 STABILIZE SANDBLAST GRIT-CONTAMINATED SOIL AND PLACE IN OFA/PENNWALT AREA

Activity	Quantity	Unit	Cost	Total
Remediation				
Mobilization	1	EA	\$40,000	\$40,000
Stabilize Grit Contaminated Soil	800	CY	\$85	\$68,000
Place Stabilized Soil	1,500	CY	\$12	\$18,000
Asphalt Paving (2-1/2")	221	TON	\$27	\$5,967
Fabric Interlayer and Seal Coat	1,600	SY	\$3.05	\$4,880
8" Sand and gravel cover	622	TON	\$6	\$3,732
Crushed rock (4")	493	TON	\$12	\$5,916
Subtotal				\$146,495
Contingency (15%)				\$21,974
Subtotal				\$168,469
Engineering Administration (12%)				\$20,216
WSST (7.8%)				\$13,141
TOTAL				\$201,826

SANDBLAST GRIT-CONTAMINATED SOIL ALTERNATIVES COST ESTIMATE

4 RECYCLE SANDBLAST GRIT-CONTAMINATED SOIL

Activity	Quantity	Unit	Cost	Total
Remediation				
Mobilization	1	EA	\$5,000	\$5,000
Excavate	800	CY	\$2.00	\$1,600
Haul	1,350	TON	\$10	\$13,500
Disposal	1,350	TON	\$30	\$40,500
Subtotal				\$60,600
Contingency (15%)				\$9,090
Subtotal				\$69,690
Engineering Administration (12%)				\$8,363
WSST (7.8%)				\$5,436
TOTAL				\$83,489

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PAH-CONTAMINATED MATERIAL ALTERNATIVES COST ESTIMATE

1 LANDFILL BRIQUETTES/COVER PAH-CONTAMINATED SOIL
ASSUMING PETITION FOR EXEMPTION APPROVED

Activity	Quantity	Unit	Cost	Total
Remediation				
Cover Soil				
Costs covered in slag estimate	0	EA	\$0	\$0
Subtotal				\$0
Landfill Briquettes				
Mobilization	1	EA	\$3,000	\$3,000
Excavate Briquettes	4,100	CY	\$0.85	\$3,485
Disposal to Landfill	6,200	TON	\$58	\$359,600
Backfill	6,200	TON	\$6	\$37,200
Subtotal				\$403,285
Contingency (15%)				\$60,493
Subtotal				\$463,778
Engineering Administration (12%)				\$55,653
WSST (7.8%)				\$36,175
TOTAL				\$555,606

2 LANDFILL BRIQUETTES/STABILIZE PAH-CONTAMINATED SOIL

Activity	Quantity	Unit	Cost	Total
Remediation				
Stabilize Soil				
Mobilization	1	EA	\$55,000	\$55,000
Excavate Soil	9,250	CY	\$0.85	\$7,863
Stabilize Soil	9,250	CY	\$80	\$740,000
Backfill	11,100	TON	\$2	\$22,200
Subtotal				\$825,063
Contingency (15%)				\$123,759
Subtotal				\$948,822
Engineering Administration (12%)				\$113,859
WSST (7.8%)				\$74,008
Subtotal				\$1,136,689
Landfill Briquettes				
Mobilization	1	EA	\$3,000	\$3,000
Excavate Briquettes	4,100	CY	\$0.85	\$3,485
Disposal to Landfill	6,200	TON	\$58	\$359,600
Backfill	6,200	TON	\$6	\$37,200
Subtotal				\$403,285
Contingency (15%)				\$60,493
Subtotal				\$463,778
Engineering Administration (12%)				\$55,653
WSST (7.8%)				\$36,175
Subtotal				\$555,606
TOTAL				\$1,692,294

PAH-CONTAMINATED MATERIAL ALTERNATIVES COST ESTIMATE

3 LANDFILL BRIQUETTES/LANDFILL PAH-CONTAMINATED SOIL

Activity	Quantity	Unit	Cost	Total
Remediation				
Landfill Soil				
Mobilization	1	EA	\$3,000	\$3,000
Excavate Soil	9,250	CY	\$0.85	\$7,863
Disposal to Landfill	11,100	TON	\$70	\$777,000
Backfill	11,100	TON	\$2	\$22,200
Subtotal				\$810,063
Contingency (15%)				\$121,509
Subtotal				\$931,572
Engineering Administration (12%)				\$111,789
WSST (7.8%)				\$72,663
Subtotal				\$1,116,023
Landfill Briquettes				
Mobilization	1	EA	\$3,000	\$3,000
Excavate Briquettes	4,100	CY	\$0.85	\$3,485
Disposal to Landfill	6,200	TON	\$58	\$359,600
Backfill	6,200	TON	\$6	\$37,200
Subtotal				\$403,285
Contingency (15%)				\$60,493
Subtotal				\$463,778
Engineering Administration (12%)				\$55,653
WSST (7.8%)				\$36,175
Subtotal				\$555,606
TOTAL				\$1,671,629

4 BURN BRIQUETTES/COVER PAH-CONTAMINATED SOIL

Activity	Quantity	Unit	Cost	Total
Remediation				
Cover Soil				
Costs covered in slag estimate	0	EA	\$0	\$0
Subtotal				\$0
Burn Briquettes				
Mobilization	1	EA	\$3,000	\$3,000
Excavate Briquettes	4,100	CY	\$0.85	\$3,485
Transport briquettes	6,200	TON	\$22	\$136,400
Burn Briquettes	6,200	TON	\$100	\$620,000
Subtotal				\$762,885
Contingency (15%)				\$114,433
Subtotal				\$877,318
Engineering Administration (12%)				\$105,278
WSST (7.8%)				\$68,431
TOTAL				\$1,051,027

PAH-CONTAMINATED MATERIAL ALTERNATIVES COST ESTIMATE

5 BURN BRIQUETTES/STABILIZE PAH-CONTAMINATED SOIL

Activity	Quantity	Unit	Cost	Total
Remediation				
Stabilize Soil				
Mobilization	1	EA	\$55,000	\$55,000
Excavate Soil	9,250	CY	\$0.85	\$7,863
Stabilize Soil	9,250	CY	\$80	\$740,000
Backfill	11,100	TON	\$2	\$22,200
Subtotal				\$825,063
Contingency (15%)				\$123,759
Subtotal				\$948,822
Engineering Administration (12%)				\$113,859
WSST (7.8%)				\$74,008
Subtotal				\$1,136,689
Burn Briquettes				
Mobilization	1	EA	\$3,000	\$3,000
Excavate Briquettes	4,100	CY	\$0.85	\$3,485
Transport briquettes	6,200	TON	\$22	\$136,400
Burn Briquettes	6,200	TON	\$100	\$620,000
Subtotal				\$762,885
Contingency (15%)				\$114,433
Subtotal				\$877,318
Engineering Administration (12%)				\$105,278
WSST (7.8%)				\$68,431
Subtotal				\$1,051,027
TOTAL				\$2,187,715

PAH-CONTAMINATED MATERIAL ALTERNATIVES COST ESTIMATE

6 BURN BRIQUETTES/LANDFILL PAH-CONTAMINATED SOIL

Activity	Quantity	Unit	Cost	Total
Remediation				
Landfill Soil				
Mobilization	1	EA	\$3,000	\$3,000
Excavate Soil	9,250	CY	\$0.85	\$7,863
Disposal to Landfill	11,100	TON	\$70	\$777,000
Backfill	11,100	TON	\$2	\$22,200
Subtotal				\$810,063
Contingency (15%)				\$121,509
Subtotal				\$931,572
Engineering Administration (12%)				\$111,789
WSST (7.8%)				\$72,663
Subtotal				\$1,116,023
Burn Briquettes				
Mobilization	1	EA	\$3,000	\$3,000
Excavate Briquettes	4,100	CY	\$0.85	\$3,485
Transport briquettes	6,200	TON	\$22	\$136,400
Burn Briquettes	6,200	TON	\$100	\$620,000
Subtotal				\$762,885
Contingency (15%)				\$114,433
Subtotal				\$877,318
Engineering Administration (12%)				\$105,278
WSST (7.8%)				\$68,431
Subtotal				\$1,051,027
TOTAL				\$2,167,050

7 INCINERATE BRIQUETTES/COVER PAH-CONTAMINATED SOIL

Activity	Quantity	Unit	Cost	Total
Remediation				
Cover Soil				
Costs covered in slag estimate	0	EA	\$0	\$0
Subtotal				\$0
Incinerate Briquettes				
Mobilization	1	EA	\$3,000	\$3,000
Excavate Briquettes	4,100	CY	\$0.85	\$3,485
Transport briquettes	6,200	TON	\$40	\$248,000
Incinerate Briquettes	6,200	TON	\$750	\$4,650,000
Backfill	4,920	TON	\$6	\$29,520
Subtotal				\$4,934,005
Contingency (15%)				\$740,101
Subtotal				\$5,674,106
Engineering Administration (12%)				\$680,893
WSST (7.8%)				\$442,580
TOTAL				\$6,797,579

PAH-CONTAMINATED MATERIAL ALTERNATIVES COST ESTIMATE

8 INCINERATE BRIQUETTES/STABILIZE PAH-CONTAMINATED SOIL

Activity	Quantity	Unit	Cost	Total
Remediation				
Stabilize Soil				
Mobilization	1	EA	\$55,000	\$55,000
Excavate Soil	9,250	CY	\$0.85	\$7,863
Stabilize Soil	9,250	CY	\$80	\$740,000
Backfill	11,100	TON	\$2	\$22,200
Subtotal				\$825,063
Contingency (15%)				\$123,759
Subtotal				\$948,822
Engineering Administration (12%)				\$113,859
WSST (7.8%)				\$74,008
Subtotal				\$1,136,689
Incinerate Briquettes				
Mobilization	1	EA	\$3,000	\$3,000
Excavate Briquettes	4,100	CY	\$0.85	\$3,485
Transport briquettes	6,200	TON	\$40	\$248,000
Incinerate Briquettes	6,200	TON	\$750	\$4,650,000
Backfill	4,920	TON	\$6	\$29,520
Subtotal				\$4,934,005
Contingency (15%)				\$740,101
Subtotal				\$5,674,106
Engineering Administration (12%)				\$680,893
WSST (7.8%)				\$442,580
Subtotal				\$6,797,579
TOTAL				\$7,934,267

PAH-CONTAMINATED MATERIAL ALTERNATIVES COST ESTIMATE

9 INCINERATE BRIQUETTES/LANDFILL PAH-CONTAMINATED SOIL

Activity	Quantity	Unit	Cost	Total
Remediation				
Landfill Soil				
Mobilization	1	EA	\$3,000	\$3,000
Excavate Soil	9,250	CY	\$0.85	\$7,863
Disposal to Landfill	11,100	CY	\$70	\$777,000
Backfill	11,100	TON	\$2	\$22,200
Subtotal				\$810,063
Contingency (15%)				\$121,509
Subtotal				\$931,572
Engineering Administration (12%)				\$111,789
WSST (7.8%)				\$72,663
Subtotal				\$1,116,023
Incinerate Briquettes				
Mobilization	1	EA	\$3,000	\$3,000
Excavate Briquettes	4,100	CY	\$0.85	\$3,485
Transport Briquettes	6,200	TON	\$40	\$248,000
Incinerate Briquettes	6,200	TON	\$750	\$4,650,000
Backfill	4,920	TON	\$6	\$29,520
Subtotal				\$4,934,005
Contingency (15%)				\$740,101
Subtotal				\$5,674,106
Engineering Administration (12%)				\$680,893
WSST (7.8%)				\$442,580
Subtotal				\$6,797,579
TOTAL				\$7,913,602

10 PAVE PAH-CONTAMINATED AREA

Activity	Quantity	Unit	Cost	Total
Remediation				
Cover area with pavement				
Mobilization (covered)	0	EA	\$0	\$0
Site Grading (covered)	0	ACRE	\$0	\$0
Fill (covered)	0	TON	\$0	\$0
Crushed rock (6")	2,686	TON	\$12	\$32,232
Asphalt Paving (2-1/2")	1,085	TON	\$27	\$29,295
Fabric Interlayer and Seal Coat	8,444	SY	\$3	\$25,754
8" Sand and gravel cover	3,000	TON	\$6	\$18,000
Subtotal				\$105,281
Contingency (15%) (covered)				\$0
Subtotal				\$105,281
Engineering Administration (12%) (covered)				\$0
WSST (7.8%)				\$8,212
TOTAL				\$113,493

(covered) = item costs covered in slag estimate

PREFERRED ALTERNATIVE FOR OFA SLAG/SOIL (NO. 3), PAH-CONTAMINATED SOIL (NO. 1)
AND SANDBLAST GRIT-CONTAMINATED SOIL (NO. 2)
ALTERNATIVES COST ESTIMATE

Activity	Quantity	Unit	Unit Cost	Total Cost
Remediation				
Mobilization	1	EA	\$20,000	\$20,000
Excavate and Dispose of Charcoal	1	EA	\$403,285	\$403,285
Site Grading (Cut & Fill with existing material)	17	ACRE	\$1,000	\$17,000
Haul and Place Sandblast Grit	1,000	CY	\$6	\$6,000
Crushed Rock (6") - Over Grit	493	TON	\$12	\$5,916
Asphalt Paving (2-1/2") - Over Grit	221	TON	\$27	\$5,967
Fabric Interlayer and Seal Coat	1,600	SY	\$3	\$4,800
8" Sand and Gravel Cover over Asphalt	622	TON	\$6	\$3,732
Fill and Cap (Material, handling, placement and compaction) 2' Cap	92,400	TON	\$6	\$554,400
Groundwater Monitoring - 8 wells				
Yearly for 2 years (metals)	2	YR	\$10,000	\$20,000
Subtotal				\$1,041,100
Contingency (15%)				\$156,165
Subtotal				\$1,197,265
Engineering Administration (12%)				\$143,672
WSST (7.8%)				\$93,387
TOTAL				\$1,434,323

COMBINED BLAIR BACKUP AND BLAIR WATERWAY PROPERTIES REMEDIATION
ALTERNATIVES COST ESTIMATE

SITE GRADING TO ELEVATION 15.5, PLACING GRAVING DOCK SLAG OVER 17 ACRES,
AND CAPPING WITH A PAVEMENT SECTION (OPTION A)

Activity	Quantity	Unit	Unit Cost	Total Cost
Remediation				
Mobilization	1	EA	\$40,000	\$40,000
Site Grading (Cut & Fill w/ Existing Mat'l)	17.0	ACRE	\$1,000	\$17,000
Fill (Material, hauling, placement, and compaction) (6" below slag)	25,000	TON	\$6	\$150,000
Excavate and Dispose of Charcoal	1	CY	\$403,285	\$403,285
Transport, Place & Compact Sand Blast Grit	1,000	CY	\$6	\$6,000
Place & Compact Blair Waterway Slag	19,500	CY	\$3	\$58,500
Crushed Rock (6")	25,370	TON	\$12	\$304,440
Asphalt Paving (4")	11,424	TON	\$27	\$308,448
Fabric Interlayer and Seal Coat	82,280	SY	\$3.05	\$250,954
Catch Basins	12	EA	\$1,100	\$13,200
24-inch Diameter Corrugated Metal Pipe	3,080	LF	\$20	\$61,600
8" Sand and Gravel Cover on Asphalt	32,000	TON	\$6	\$192,000
Groundwater Monitoring – 8 wells monitored	2	YR	\$10,000	\$20,000
Subtotal				\$1,825,427
Contingency (15%)				\$273,814
Subtotal				\$2,099,241
Engineering/Administration (12%)				\$251,909
WSST (7.8%)				\$163,741
TOTAL				\$2,514,891

NOTES:

- This option does not include costs to excavate slag from Blair Waterway property and transport slag material to the Blair Backup property.
- This option assumes a 6-inch buffer layer will be placed beneath the Blair Waterway slag.
- Groundwater monitoring will entail sampling eight existing wells and monitoring for metals and PAH annually for two years.

COMBINED BLAIR BACKUP AND BLAIR WATERWAY PROPERTIES REMEDIATION
ALTERNATIVES COST ESTIMATE

SITE GRADING TO ELEVATION 15.5, PLACING GRAVING DOCK SLAG OVER 7 ACRES,
AND CAPPING WITH A PAVEMENT SECTION (OPTION B)

Activity	Quantity	Unit	Unit Cost	Total Cost
Remediation				
Mobilization	1	EA	\$40,000	\$40,000
Site Grading (Cut & Fill w/ Existing Mat'l)	17.0	ACRE	\$1,000	\$17,000
Fill (Material, hauling, placement, and compaction) (6" below slag)	9,900	TON	\$6	\$59,400
Excavate and Dispose of Charcoal	1	CY	\$403,285	\$403,285
Transport, Place & Compact Sand Blast Grit	1,000	CY	\$6	\$6,000
Place & Compact Blair Waterway Slag	19,500	CY	\$3	\$58,500
Crushed Rock (6")	10,450	TON	\$12	\$125,400
Asphalt Paving (2-1/2")	4,704	TON	\$27	\$127,008
Fabric Interlayer and Seal Coat	33,880	SY	\$3.05	\$103,334
Cap Remaining Site (2 foot Sand and Gravel)	56,630	TON	\$6	\$339,780
8" Sand and Gravel Cover on Asphalt	13,200	TON	\$6	\$79,200
Groundwater Monitoring - 8 wells monitored	2	YR	\$10,000	\$20,000
Subtotal				\$1,378,907
Contingency (15%)				\$206,836
Subtotal				\$1,585,743
Engineering/Administration (12%)				\$190,289
WSST (7.8%)				\$123,688
TOTAL				\$1,899,720

NOTES:

- This option does not include costs to excavate slag from Blair Waterway property and transport slag material to the Blair Backup property.
- This option assumes a 6-inch buffer layer will be placed beneath the Blair Waterway slag.
- This option assumes that catch basins are not required in the 7 acre area. Drainage will be runoff to surrounding capped area.
- Groundwater monitoring will entail sampling eight existing wells and monitoring for metals and PAH annually for two years.

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OFA SLAG/SOIL REMEDIATION ALTERNATIVES COST ESTIMATES

#1 BASELINE CONDITION

Activity	Quantity	Unit	Unit Cost	Total Cost
Review Data	1	EA	\$2,000	\$2,000
Subtotal				\$2,000
Contingency (15%)				\$300
Subtotal				\$2,300
Engineering/Administration (12%)				\$276
WSST (7.8%)				\$179
TOTAL				\$2,755

#2 SITE GRADING AND EROSION/DUST CONTROL

Activity	Quantity	Unit	Unit Cost	Total Cost
Remediation				
Mobilization	1	EA	\$8,000	\$8,000
Site Grading (Cut & Fill w/ Existing Mat'l)	17.0	ACRE	\$1,000	\$17,000
Erosion/Dust Control	17.0	ACRE	\$5,000	\$85,000
Subtotal				\$110,000
Contingency (15%)				\$16,500
Subtotal				\$126,500
Engineering/Administration (12%)				\$15,180
WSST (7.8%)				\$9,867
TOTAL				\$151,547

#3 SITE GRADING, FILLING TO TAYLOR WAY ELEVATION, AND CAPPING WITH WELL GRADED SAND AND GRAVEL

Activity	Quantity	Unit	Unit Cost	Total Cost
Remediation				
Mobilization	1	EA	\$10,000	\$10,000
Site Grading (Cut & Fill w/ Existing Mat'l)	17.0	ACRE	\$1,000	\$17,000
Fill & Cap (Material, hauling, placement, and compaction) 2' Cap	103,890	TON	\$6	\$623,340
Subtotal				\$650,340
Contingency (15%)				\$97,551
Subtotal				\$747,891
Engineering/Administration (12%)				\$89,747
WSST (7.8%)				\$58,335
TOTAL				\$895,973

OFA SLAG/SOIL REMEDIATION ALTERNATIVES COST ESTIMATES

#4 SITE GRADING, FILLING TO TAYLOR WAY ELEVATION, AND CAPPING WITH A LOW PERMEABLE SOIL

Activity	Quantity	Unit	Unit Cost	Total Cost
Remediation				
Mobilization	1	EA	\$10,000	\$10,000
Site Grading (Cut & Fill w/ Existing Mat'l)	17.0	ACRE	\$1,000	\$17,000
Cap (Material, hauling, placement, and compaction) 2' Cap	92,340	TON	\$8	\$738,720
Subtotal				\$765,720
Contingency (15%)				\$114,858
Subtotal				\$880,578
Engineering/Administration (12%)				\$105,669
WSST (7.8%)				\$68,685
TOTAL				\$1,054,932

#5 SITE GRADING, FILLING TO TAYLOR WAY ELEVATION, AND CAPPING WITH A PAVEME SECTION

Activity	Quantity	Unit	Unit Cost	Total Cost
Remediation				
Mobilization	1	EA	\$40,000	\$40,000
Site Grading (Cut & Fill w/ Existing Mat'l)	17.0	ACRE	\$1,000	\$17,000
Fill (Material, hauling, placement, and compaction) (1.5')	78,910	TON	\$6	\$473,460
Crushed Rock (4")	16,913	TON	\$12	\$202,960
Asphalt Paving (2")	9,135	TON	\$27	\$246,645
Catch Basins	12	EA	\$1,100	\$13,200
24-inch Diameter Corrugated Metal Pipe	3,080	LF	\$20	\$61,600
Subtotal				\$1,054,865
Contingency (15%)				\$158,230
Subtotal				\$1,213,095
Engineering/Administration (12%)				\$145,571
WSST (7.8%)				\$94,621
TOTAL				\$1,453,288

OFA SLAG/SOIL REMEDIATION ALTERNATIVES COST ESTIMATES

#6 OVEREXCAVATION OF SOIL, DISPOSAL TO LANDFILL, BACKFILLING WITH STRUCTURAL FILL, SITE GRADING, AND EROSION/DUST CONTROL

Activity	Quantity	Unit	Unit Cost	Total Cost
Remediation				
Mobilization	1	EA	\$3,000	\$3,000
Bark Removal and Disposal	13,660	CY	\$8.60	\$117,476
Excavate Slag/Soil Material	80,000	CY	\$0.85	\$68,000
Disposal (Incl. waste characterization/profiling, hauling and disposal)	158,850	TON	\$75	\$11,913,750
Backfill	140,400	TON	\$6	\$842,400
Site Grading	17.0	ACRE	\$930	\$15,810
Erosion/Dust Control	17.0	ACRE	\$5,000	\$85,000
Subtotal				\$13,045,436
Contingency (15%)				\$1,956,815
Subtotal				\$15,002,251
Engineering/Administration (12%)				\$1,800,270
WSST (7.8%)				\$1,170,176
TOTAL				\$17,972,697

#7 OVEREXCAVATION OF SOIL, SOLIDIFICATION/STABILIZATION, BACKFILLING WITH SOLIDIFIED SOIL, SITE GRADING, AND EROSION/DUST CONTROL

Activity	Quantity	Unit	Unit Cost	Total Cost
Remediation				
Mobilization	1	EA	\$55,000	\$55,000
Bark Removal and Disposal	13,660	CY	\$8.60	\$117,476
Excavate Slag/Soil Material	80,000	CY	\$0.85	\$68,000
Stabilize Slag/Soil	80,000	CY	\$80	\$6,400,000
Backfill	154,450	TON	\$2	\$308,900
Site Grading	17.0	ACRE	\$930	\$15,810
Erosion/Dust Control	17.0	ACRE	\$5,000	\$85,000
Subtotal				\$7,050,186
Contingency (15%)				\$1,057,528
Subtotal				\$8,107,714
Engineering/Administration (12%)				\$972,926
WSST (8.2%)				\$664,833
TOTAL				\$9,745,472

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**APPENDIX H
EXCAVATION, STOCKPILING, AND
CHARACTERIZATION OF SANDBLAST GRIT
BLAIR BACKUP PROPERTY
PORT OF TACOMA**

**APPENDIX H
EXCAVATION, STOCKPILING, AND
CHARACTERIZATION OF SANDBLAST GRIT
BLAIR BACKUP PROPERTY
PORT OF TACOMA**

It is believed that sandblast grit has been disposed of at the Blair Backup property, owned by the Port of Tacoma, over a period of several years. This material was placed on the ground surface in five general areas and was interlaid with natural soils. The five areas have been identified as Areas A, B, C, D, and F based on their locations.

Between December 17 and 19, 1991, approximately 400 cubic yards of sandblast grit were excavated from the five sandblast grit areas. Sandblast grit and soil removed from these five areas were stockpiled separately on site and covered with visqueen.

After obtaining verification test results from the five areas, an additional 350 cubic yards of sandblast grit were removed from Areas D and F between February 14 and 20, 1992. This material was also stockpiled and covered on site.

The second round of verification test results indicated additional sandblast grit material from Area F required excavation. Consequently, on April 24, 1992, approximately 15 cubic yards of sandblast grit was removed from Area F and stockpiled on site.

The third round of verification test results indicated additional sandblast grit material from Area F required excavation. On June 5, 1992, approximately 5 cubic yards of sandblast grit was removed and stockpiled on site. This completed the excavation and stockpiling portion of work for the sandblast grit at the Blair Backup property. Table H-1 summarizes the estimated quantities of stockpiled sandblast grit.

*Summarize
of samples that
exceed 100 ppm +
that exceed
TCLP Ver.*

Table H-1 - Estimated Sandblast Grit Quantities

Area	Sandblast Grit Excavated and Stockpiled in cy				Estimated Total
	<u>12/17 - 19/91</u>	<u>2/14 - 20/92</u>	<u>4/24/92</u>	<u>6/5/92</u>	
A and B	10				
C	10				
D	300	340			
F	<u>80</u>	<u>10</u>	<u>15</u>	<u>5</u>	
	400	350	15	5	770

Analytical Test Results

In December 1991, samples were collected from the sandblast grit stockpiles for chemical analysis. The stockpile samples were initially analyzed for toxicity characteristics leaching procedure (TCLP) metals in accordance with EPA Method 1311 by Laucks Testing Laboratory. The stockpile sample from Areas A and B were combined for the TCLP metals analysis.

Acute fish bioassay tests were also performed on the stockpile samples from the sandblast grit excavation. These tests were performed in accordance with Washington State Department of Ecology Static Acute Fish Toxicity Test (Publication DOE 80-12) at 1,000 ppm. The stockpile sample from Areas A, B, and C were combined for the fish bioassay test. Data from the TCLP metals and fish bioassay tests are presented in Table H-2.

In June 1992, a second set of samples were collected from the sandblast grit stockpiled soils. Composites, each representing roughly 100 cubic yards, were taken and analyzed for total arsenic (Method 7061) (See Table H-3).

Attachment H-1 presented in Volume II presents the Certificates of Analysis of verification sampling and validation report for the sandblast grit.

Table H-2 - Sandblast Grit Stockpile Data - Total Arsenic

Stockpile Designation	Sample Number	Total Arsenic in mg/kg (DB)	Total Solids in %
A/B	PIP3	140	99.5
D1	D1-1	600	95.4
	D1-3	650	96.2
	D1-5	660	95.7
D2/E	D2-1	360	94.9
	D2-1	420	95.3
	D2-5	630	97.0
	D2-7	230	94.7
F	F1	590	95.9
G1/G2	G-1-1	630	95.2

Table H-3 - Sandblast Grit Stockpile Data - TCLP and Acute Fish Bioassay

	<u>Area A/B</u>		<u>Area C</u>		<u>Area D</u>				<u>Area F</u>							
<u>Analysis</u>																
TCLP metals in mg/L																
	SP-AB		SP-C		SP-1		SP-2		SP-6		SP-F-N		SP-F-S			
Arsenic	0.2	U	0.2	U	0.2	U	0.41		0.6		0.2	U	0.2	U		
Barium	1.7		0.8		0.7		0.66		1.1		1.3		1.3			
Cadmium	0.01		0.01	U	0.01	U	0.01	U	0.01	U	0.06		0.09			
Chromium	0.2		0.1	U	0.1	U	0.1	U	0.1	U	0.1		0.16			
Copper	2		19		0.47		1.2		2		2.1		2.8			
Lead	0.2		0.1	U	0.2		0.17		0.36		0.1	U	0.1			
Mercury	0.005	U	0.006		0.005	U	0.005	U	0.005	U	0.005	U	0.005	U		
Nickel	0.2		0.1	U	0.34		0.24		0.27		0.1	U	0.1	U		
Selenium	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U		
Silver	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U		
Zinc	25		29		14		4.9		2.9		2.9		3.7			
U Constituent not detected at concentration indicated																
	<u>Area A/B/C</u>				<u>Area D</u>				<u>Area F</u>							
Acute Fish Bioassay																
(No. of deaths/ total fish exposed)																
5/30																
1/30																
1/30																

Sandblast Grit Stockpile Location Plan



F Sandblast Grit Stockpile Location and Designation

Note: Base map prepared from aerial photograph of the Port of Tacoma dated June 1, 1989.



0 400 800
Approximate Scale in Feet